The Engineer

LONDON, FRIDAY, DECEMBER 18, 1942.

PUBLIC NOTICES

GAN AND DISTRICT MINING ND TECHNICAL COLLEGE

Governing Body Invites

APPLICATIONS for the POST of of the ENGINEERING DEPARTMENT, becoming vacant through the retirement S. H. Moorfield, M.Sc., A.M.I. Mech. E. will commence on 1st April, 1943, or as possible thereafter.

lidates should possess (a) high academic estions, (b) industrial experience, and ching experience (preferably in a technical or university). Salary scale: £560-£20-

ther particulars and application form will nt by the undersigned on receipt of a ed, addressed foolscap envelope. Last date receipt of applications, 9th January, 1943.

J. F. S. ROSS,
Principal and Clerk to the
Governing Body.

December, 1942. 9111

SITUATIONS OPEN

ES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

the benefit of applicants, the Proprietors epared to insert brief notices that vacancies lled, upon receipt of notifications from the rtisers. These notices (limited to one line) be free of charge, and co-operation is for.

IMPORTANT

rtisers in Situations Open Column ld make themselves acquainted with terms of

TATUTORY RULES & ORDERS
1941 No. 2069
TRICTION ON ENGAGEMENT ORDER

The Directors of WILLFORD & CO., Ltd., of Sheffield, DESIRE to THANK the APPLIANTS for the Vacancy of Managing Director, h position has now been filled. 9128 A

HEDULED MANUFACTURING COMPANY REQUIRE the SERVICES of a MAN to ise and Control Production Progress. uction experience in Light Engineering an Control of labour and drive essential.— ss, stating age and salary required, giving particulars of experience, 9113, The Engineer e. 9113 A

VACANCY OCCURS for MAN with Executive ability to Take Charge of Fitting and mbly Lines in large Aircraft Factory. Must had experience in similar capacity. Please stating age, experience, and salary re- d.—Address, 9084, The Engineer Office. 9084 A

ITOR WANTED. Only "All-round" Engineers should apply. Journalistic exence in the Machinery, Tools, Engineering, Electrical Trade essential. Send curriculum e and fullest particulars, stating qualifica- and salary required, &c.—Address, 9118, The ineer Office. 9118 A

NGINEER (Mechanical) REQUIRED for Permanent post on work of first national rtance. Requirements: Excellent general technical education, apprenticeship, and utive experience covering large-scale proion. Age not over 42. Salary £1000 p.a., h rapid advancement to suitable man.— lications, which are confidential, must de full details of qualifications, positions , and salaries received, Box 286, Strand se, London, W.C.2. 9085 A

ORGE MANAGER REQUIRED for Firm of Engineers and Forgemasters in Manchester rict; must have had practical experience in mer-made Forgings, Upset Forgings, and p Stampings.—Address, stating age, qualifitions, and salary required, 9115, The Engineer e. 9115 A

EAD FOREMAN REQUIRED for Small TOOL-ROOM in West London; must be to take Full Charge. High-class work only eceiver gauges, &c.—Address, stating experi- e, salary required, and when free, 9117, The ineer Office. 9117 A

EQUIRED, EXECUTIVE for Machine Shop, Tool Room, Press Shop, &c., for large ks. Please reply, stating age, experience, and ary required.—Address, 9082, The Engineer e. 9082 A

The Engineer

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SITUATIONS OPEN

REQUIRED, PRODUCTION and PLANNING ENGINEER, with administrative ability, for large factory. Must have had considerable experience. Please reply, stating age, experience, and salary required.—Address, 9083, The Engineer Office. 9083 A

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SITUATIONS OPEN

THE Post You are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for the cost of Four Lines, 6s.; 1s. 6d. for each Additional Line. There is no better way of covering so large a field for such a small charge.

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WORKS MANAGER for Steel Tube Trade, Midlands (Rolling and Drawing), capable administrator. State qualifications fully and salary required. Permanency and post-war prospects.—Address, 9114, The Engineer Office. 9114 A

SITUATIONS WANTED

ABLE EXECUTIVE ENGINEER, Age 38, specialist mechanical and marine, good knowledge electrical, present works engineer, SEEKS RESPONSIBLE APPOINTMENT where competence and energy appreciated. Commencing salary £600. London district preferred.—Address, P5545, The Engineer Office. P5545 B

SITUATIONS WANTED

CHIEF ENGINEER of a Paper Mill, Age 38, very keen on his work, REQUIRES CHANGE; thoroughly experienced in the installation and maintenance of plant running night and day. Progressive and responsible position wanted.—Address, P5550, The Engineer Office. P5550 B

CIVIL ENGINEER, M. Inst. C.E., DESIRES WARTIME ENGAGEMENT. Highest qualifications in general civil engineering.—Address, P5532, The Engineer Office. P5532 B

CIVIL ENGINEER (33), Varied Experience construction and maintenance of docks, inland waterways, &c., including general administration and staff control, AVAILABLE SHORTLY for RESPONSIBLE POSITION.—Address, P5552, The Engineer Office. P5552 B

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ENGINEER (43), Experienced Plant Maintenance, steam, power, air, water, chemicals, REQUIRES CHANGE to improve position and more usefully occupy his ability.—Address, P5544, The Engineer Office. P5544 B

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TRACER, Free January 11th, REQUIRES SITUATION; W., S.W.1, districts preferred; five-day week. Specimens of work available.—Address, P5519, The Engineer Office. P5519 B

WORKS ENGINEER DESIRES CHANGE. Wide experience in electrical and mechanical maintenance, steam power plant, heavy millwrighting, hydraulics, pneumatics, coal gas producers, overhead cranes and lifting gear.—Address, P5551, The Engineer Office. P5551 B

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CLASSIFIED ADVERTISEMENTS CLOSE FOR
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The Engineer

Annual Subscription Rates

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CANADA	£2	18	6
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(except Canada)

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The Charges for Classified Advertisements are 1/6 per line up to one inch—minimum charge, 6/-; those occupying one inch or more at the rate of 18/- per inch. Box numbers, 1/- extra, except in the case of advertisements under "Situations Wanted." Orders MUST be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher; all other letters are to be addressed to the Editor of THE ENGINEER.

Postal Address,
28, Essex Street, Strand, London, W.C.2.

Teleg. Address,
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Tel., Central 6565 (10 lines).

PARTNERSHIPS

CHARTERED ENGINEER, with Extensive engineering, manufacturing, and commercial experience, WOULD LIKE to CONTACT PRINCIPALS interested in forming engineering organisation to manufacture vital war products carrying highest priority for all essentials. Excellent post-war development prospects; home and export markets.—Address, 9120, The Engineer Office. 9120 C

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WANTED, CIRCULAR COLD SAW (Metal Sawing), capacity 24in. diameter.—Details and price to "J.F.," Staffa Works, Staffa Road, Leyton, E.10. 9106 F

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Owing to the premature completion of a Government demand, we have the following maximum capacity, available for rough or finished machining, long-term work preferred:—

CENTRE LATHE, S.S. and S.: Bar work, max. 12in. dia. by 4ft. long; chuck work, max. 2ft. 6in. dia. in a 10in. gap. Available on January 12th (for 75 hours per week).

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MISCELLANEOUS

BOUND VOLUMES or COPIES of "ENGINEER," January to June, 19[illegible] January to June, 1937, WANTED.—F. M. P. (or telephone Central 6565), The Engineer Office.

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Send threepence in stamps for our book "STEEPLE-JACKERY."

FOR SALE, TALC (French Chalk), [illegible] delivery.—LEONARD BAINED and [illegible], 11, Old Hall Street, Liverpool.

For continuation of Small Advertisements see page 56.

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ACETYLENE GENERAT[illegible]
THE BRITISH GENERATOR MFG. Co.[illegible]
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S.W.19

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A Seven-Day Journal

Employment Returns

THE Employment Returns, which were issued by the Ministry of Labour and National Service on Friday, December 11th, state that the number of men and boys registered at Employment Exchanges in Great Britain as wholly unemployed at November 16th, 1942 (exclusive of 22,579 men who had been classified by interviewing panels as unsuitable for ordinary industrial employment), was 59,151; those registered as on short time or otherwise temporarily suspended from work on the understanding that they were shortly to return to their former employment numbered 1359; and those registered as unemployed casual workers (being persons who normally seek their livelihood by jobs of short duration) numbered 2592. As compared with October 12th, the numbers wholly unemployed showed a decrease of 1618, those temporarily suspended from work showed an increase of two, and unemployed casual workers showed a decrease of 154. The corresponding figures for women and girls at November 16th were 31,511 wholly unemployed (exclusive of those, numbering 956, who had been classified by interviewing panels as unsuitable for normal full-time employment), 684 temporarily stopped, and 148 unemployed casual workers. Of the 31,511 wholly unemployed, 1055 had been classified as unable for good cause to transfer to another area. As compared with October 12th, the numbers wholly unemployed showed a decrease of 3737, those temporarily stopped showed a decrease of 158, but unemployed casual workers showed an increase of 27. During the whole of the period under review, unemployment fell in all the administrative regions, with the exception of the Southern Area, in which a slight increase in unemployment was recorded.

New Canadian Water Power Scheme

IN the course of a speech made in Montreal on Friday, December 11th, Mr. C. D. Howe, the Canadian Minister of Munitions and Supply, revealed that Canada had undertaken somewhere in her vast hinterland the wartime construction of a large hydro-electric power scheme which in its size and output is said to rival the famous American Boulder dam. The designed capacity of the new power plant is 1,020,000 H.P. It has been constructed under war conditions with a shortage of labour and materials and in spite of adverse weather conditions. Within a period of 18 months from beginning work electric power from the station was being used. This new development is understood to be entirely set apart for the large-scale production of aluminium and light alloys, of which Canada is already supplying about 40 per cent. of the requirements of the Allied Nations. The work was started some time after the fall of France in 1940, and at one time as many as 10,140 men were employed upon the work, which is nearly twice the number of men who were engaged on building the Boulder dam. In a recent speech Mr. George C. Batemen, the Federal Metals Controller, mentioned that when present plans had been completed, Canada would have the largest single aluminium factory in the world, having a designed output which would be equal to the whole world output in 1939. Further particulars of this interesting water power scheme will be awaited with keen interest.

The Pooling of Steel Resources

ON the evening of Monday, December 14th, it was simultaneously announced in London and Washington that Great Britain, Canada, and the United States have united in creating a Combined Steel Committee, which has as its object the squeezing out of every possible ton of steel from existing plants, in order to fulfil the combined war production programme for 1943. The new Committee has been formed by the Combined Production and Resources Board and the Combined Raw Materials Board, under the chairmanship of Mr. Hiland G. Batcheller, who is to be assisted by a staff of American, British, and Canadian experts. The instructions given to the Committee are:—(1) To obtain, assemble, and co-ordinate information on iron ore and scrap, iron and steel production, and requirements of iron and steel of the United Nations in such a form as will enable the supply and requirements position to be kept continuously under review by both Boards; (2) to consider and make recommendations on the means of increasing production, and improving the efficiency of the use of steel and distribution facilities in the United Nations, including facilitating the exchange of technical information, information on trade practices, and measures of conservation and limitation of use; (3) to consider and make recommendations on unified systems of definitions and terminology; (4) to undertake such special inquiries as may be directed by either Board; (5) to recommend as necessary any action which should be taken by either Board to adjust supplies and requirements to one another. The new Combined Steel Committee will work in Washington and will be constituted as follows: Mr. Hiland G. Batcheller, Chairman (Chief of the Iron and Steel Division, War Production Board), Major E. W. Senior (United Kingdom Iron and Steel Control and representing the British Ministry of Production), Mr. Douglas Campbell (Combined Raw Materials Board), Mr. Geoffrey Crowther (Combined Production and Resources Board), Mr. O. Heller (Iron and Steel Division, War Production Board), Mr. Paul Homan (Combined Raw Materials Board), and Mr. D. V. Collyer (Canadian Department of Munitions and Supply).

Railway Wages

ON Friday evening, December 11th, the award of the Railway Staff National Tribunal on the claims of the railwaymen's unions for wages increases was announced. It may be recalled that the National Union of Railwaymen asked for an additional amount of 10s. a week for all grades, with £26 a year for salaried staff, while the Associated Society of Locomotive Engineers and Firemen claimed increases for drivers, motormen, firemen, and engine cleaners ranging from 4s. to 12s. per week. Before the case went to the Tribunal, the railway companies offered a sum of 4s. for men with appropriate increases for the other staff. That offer was not accepted. The award of the Tribunal is 5s. a week increase to railwaymen throughout the country, with 3s. 9d. for women, 2s. 6d. for youths, and 1s. 9d. for girls. The workers on the London Passenger Transport Board's system are not affected by the award. The increases are to date from June 24th last, and the number of staff involved is about 429,000. In the case of railway staff who have already received an additional war advance this year, such as the 4s. granted to salaried staff and enginemen, the amounts received will be increased to the amounts shown above, but the advances are exclusive of the advance of 4s. 6d. a week which was awarded in a previous Tribunal decision to certain grades of the conciliation staff, other increase consequent upon that decision, and any increase in standard rates of wages or salary scales. The award is signed by three members of the Tribunal, Sir John Forster, its Chairman, and Sir Charles Bruce-Gardner, and Mr. J. Hallsworth.

A Survey of Engineering Capacity

AT the opening of the London Regional Capacity Office, which took place on Thursday, December 10th, Mr. G. M. Garro-Jones, the Parliamentary Secretary of the Ministry of Production, made reference to the survey of engineering capacity which had been made by the Ministry, and the results which were now available at eleven Regional Offices and fifty-five similar District Capacity Offices. The records would show all whom it might concern where engineering plant, labour, premises, and management were to be found. In the placing of new contracts it would now be possible to see where they could be placed without overload and without waste. The new records, Mr. Garro-Jones said, would be of value alike to main contractors and sub-contractors. The information which had been prepared would enable the Ministry to arrange that human hands and metal machines were put to the work which they could most efficiently perform. Machines would be considered in relation to their skilled and unskilled operators, and differing plants in their relation one to another. Sub-contracting arrangements which were efficient would not be disturbed, but in those cases in which sub-contracts were entered into hastily and could be shown as inefficient, they would be readjusted with as little disturbance as possible. Large and small allocations would have to be made in order to meet the changing demands of each Service and the changing priorities between each Service. The Minister of Production and his staff looked upon it as a matter for satisfaction that the records which had been obtained were compiled without any undue burden upon industry by reason of extra returns and the additional filling in of forms. The Supply Departments had arranged to have full use of the facilities, and it was equally desirable that contractors should know all about them and use them for the great ends we all had in view. After Mr. Garro-Jones had spoken, Mr. Osselton, the Principal Capacity Officer for the London Region, explained the use of the records.

Scottish Hydro-Electric Development

ON Wednesday, December 16th, it was announced that the Government has accepted the principal recommendations of the report of the Committee on Hydro-Electric Development in Scotland, and will introduce the necessary legislation early next year. The Committee was, we may recall, appointed in October, 1941, and it consisted of Lord Cooper (the Chairman), Mr. Noel Beaton, Mr. John A. Cameron, Lord Weir, and Mr. James Williamson, M. Inst. C.E., with Mr. M. R. McLarty (Advocate) as Secretary. After considering the electrical development so far effected in Northern Scotland, existing development, the comparative costs of steam and hydro-electric generation, the resources, and the utilisation of the power when generated, the Committee recommends the creation of a new public service corporation, to be called the North Scotland Hydro-Electric Board, consisting of five members, one of whom should be a member of the Central Electricity Board. The Board should be responsible for initiating and undertaking the development of all future generation of electricity in the Northern Area for public supply, and its transmission and supply in bulk to the existing undertakers. Three primary objectives in the development programme of the Board are defined by the Committee, as follows:—To attract to the Highlands through the offer of cheap and abundant power a share in the vital and expanding electro-chemical and electro-metallurgical industries; to develop such further power as may be required for the consumers of existing undertakers or for consumers in its own distribution area, the surplus being exported to the grid; and to develop on an experimental and demonstrational basis isolated schemes in isolated districts. Other recommendations refer to the priority of local requirements over other power demands, the provision of the necessary powers and financial facilities for a non-profit-earning public service corporation, and agreements with the Central Electricity Board and the Grampian Company. A note is given on the valuation and rating of hydro-electric undertakings. The report ends with some considerations on the development of water power for general supply or peak load supply, which is given in the third appendix, the first and second appendices containing the sources from which the Committee derived its evidence and a list of the authorised electricity undertakings in or adjoining the Northern Area.

Trends in the Technique of Industrial Radiography*

By HERMAN E. SEEMANN†

THE war has given tremendous impetus to the application of radiographic methods of inspection and control. The effect has been, not only to expedite the development of new apparatus and materials for industrial radiography, but also to make fuller use of previously known refinements in technique. It is the purpose of this article to review and analyse the principal factors involved in modern methods of radiographing materials.

In general, the two main problems of the radiographic method are to produce the exposure within a reasonable time, and to secure adequate sensitivity in the detection of flaws. The exposure time is governed by the "speed" of the film and of the intensifying screens (if used), and by the intensity and penetrating power of the radiation. Radiographic sensitivity is determined by the contrast and sharpness of the image, and these, in turn, depend upon factors which may, within certain limits, be modified by the operator.

Very often the factors making for shortness of exposure involve a loss in radiographic quality, and careful judgment must be exercised to select the most suitable compromise. In every case the choice of technique must be within the limitations of the equipment available. It is hoped that this review will contribute to a better understanding of the principal features of radiographic procedures, and thereby facilitate the choice of techniques for the various types of examinations.

Intensifying Screens

The established method of shortening radiographic exposure consists in using intensifying screens, with which the fluorescent radiation from the screen reinforces the direct action of the X-rays upon the film. Calcium tungstate screens emit fluorescent light, which may shorten exposures (as compared with direct X-ray exposures) by a factor of 100 or more, depending on kilovoltage and thickness of metal. Lead foil screens intensify the image by the emission of electrons and secondary X-rays, but their intensifying factor is relatively small, being rarely over 3 in practice. (See later section on "Lead Screens.") Each of these types of screen exerts its characteristic effect upon the quality of the radiograph.

It must be pointed out that the chief practical advantage of tungstate screens is the shortening of exposure time, and that the disadvantage of a certain lack of sharpness in the image naturally accompanies their use. This "unsharpness" is caused principally by the diffusion of screen light across image boundaries within the body of the screen itself. The need for salt intensifying screens arises when lead-screen exposures become too long for practical use. Creditable radiographs are being made every day with intensifying screens, but economy of exposure time is the basis for their selection.

Calcium tungstate intensifying screens are not as effective in reducing exposure times for gamma-rays as for X-rays. They would still be useful, however, if the definition were as good as it is with X-rays. In fact, intensifying screens give results of such poor quality that lead screens are generally used with gamma-rays in spite of their relatively low speed.

Care should be taken in using intensifying screens to provide perfect contact between screen and film surfaces. It is obvious that the film is bound to record only a fuzzy outline of the screen image if there is a small space in which light may spread from one part of the image to another. The use of a sturdy, rigid cassette, lined with felt and equipped with spring clips, cannot be too strongly recommended. Makeshift devices may be required for special jobs, but the need for intimate screen contact must be taken into account in every case. Excessive localised pressure must be guarded against because of the risk of producing pressure marks on the film. A simple test for contact is to radiograph a coarse wire screen placed on the cassette. Its outline will be sharp where contact is good and diffuse in regions where it is poor.

Flexible screens are of advantage in many practical cases where the film must be bent to conform to a curved surface, and these may be used with flexible cassettes made throughout of pliable rubber or with curved metal cassettes. Commercially available flexible screens are similar in radiographic properties to the ordinary type.

Intensifying screens should be handled carefully and kept as clean as possible. Actual damage is irreparable, but ordinary dirt may be removed with mild soap and water. It is difficult in many industrial plants to provide adequate care for screens, but as a rule carelessness is the chief detriment to long life. Dirt on the active face of the screen shows lighter than the surroundings in the radiograph and, if allowed to accumulate, causes unnecessary wear and interferes with the rendition of detail. Screens should never be exposed to the direct full intensity of an X-ray beam because this may excite sufficient afterglow (phosphorescence) to be recorded during the next exposure and complicate interpretation of the next image. If the cassette extends beyond the boundaries of the specimen, satisfactory reduction of intensity in this region may be obtained with a lead mask or by using a filter near the X-ray tube. Openings through a casting should be plugged with some X-ray absorbing medium, such as lead putty. Excessive exposure also tends to discolour screens and thereby to decrease their speed. In ordinary use, screens wear out mechanically before their emission is seriously impaired.

Lead Screens

The intensifying action of lead screens increases with the "hardness" of the radiation‡ at least as high as 220 kV and with increasing metal thickness. The primary rays are therefore intensified more than the longer wavelength secondary rays. Thus, the secondary radiation does not produce as great an effect on the film relative to the primary as it would if the film were used alone. Furthermore, the front screen absorbs the secondary more than it does the primary, because of the wavelength difference and also because on the average the secondary has a longer path through the front screen. Thus, we have two effects, both of which help to diminish the influence of secondary radiation in reducing contrast.

A front screen thickness of 0·005in. or 0·006in. is satisfactory for most work. All of the electrons which succeed in getting out of the foil come from a layer much thinner than this. The thickness suggested seems to be a fair compromise between sufficient absorption of secondary radiation and adequate transmission of primary radiation. A thicker back screen may be used to absorb back scatter.

Lead foil is somewhat awkward to handle, particularly since care must be used to avoid the formation of sharp wrinkles which may show in the radiograph. It is most convenient to use when mounted on a stiff support, such as cardboard. This does not affect its radiographic properties. The lead surface should be kept free from particles of dirt, since all materials are more or less strong absorbers of electrons, and will therefore leave their record in the radiograph. Lead foil for radiographic use should be selected for this purpose, otherwise there is the possibility of obtaining some tin streaks or other surface markings which may show in radiographs.

Lead screens are particularly beneficial in the radiography of small objects. A comparison of radiographs made with and without lead screens will show that the lead reduces the amount of secondary radiation undercutting the specimen around its periphery. The explanation of this is that the full intensity of the X-ray beam striking the cassette and film outside the specimen can produce enough scatter to be objectionable, when compared with the relatively low intensity which passes through the specimen. The introduction of the front lead screen decreases the undercutting of scatter by decreasing the intensity of the primary beam which causes it. The primary radiation transmitted by the specimen is quite hard, and is therefore only slightly absorbed by the lead foil.

Whether an actual reduction in exposure time is made possible by the use of lead screens depends on the relative magnitude of the several effects—absorption of primary radiation; absorption of secondary radiation; and intensification of primary and secondary radiation. These effects in turn depend upon the thickness of the specimen and the kilovoltage used. The relations are too complex to be covered by a general statement, but fortunately for practical applications, lead-screen technique is simple. It must be kept in mind that reduction in exposure time is not and should not be considered to be the chief criterion for choosing between lead-screen and direct-exposure techniques. Radiographic quality should be the primary consideration. At low voltages, the use of lead screens may actually require a longer exposure time, but if the quality is better than that in the direct exposure, their use is recommended. Conversely, the front screen should not be used when the voltage is so low that its absorption results in too low a subject contrast. (Film definition is just as good with lead screens as without.)

A test showed that in radiographing 4in. or 5in. of aluminium at 160 kV, films made with and without lead screens were of practically the same density, all exposing conditions being the same. With the aluminium placed near the X-ray tube, so as practically to eliminate secondary radiation, the lead-screen film showed considerably greater density. This illustrates the fact that intensification (adding density) may just compensate for the removal of secondary radiation

* From the *Bulletin* of the American Society for Testing Materials. March, 1942, pages 21 to 26.

† Kodak Research Laboratories.

‡ The "hardness" (or penetrating power) of X-rays is greater the higher the voltage applied to the X-ray tube, i.e., the shorter their wavelength.

(reducing density). A similar type of result was obtained with $\frac{3}{16}$in. steel exposed at 410 kV. There may be many other combinations in which intensification is just balanced by the reduction of secondary radiation.

Much of the advantage of the lead-screen technique is lost unless good contact is maintained with the film. The effect is somewhat similar to that obtained when tungstate screens are used, namely, a space between screen and film permits spreading of the emission across image boundaries. At low voltage, the intensification of the primary rays may be so slight as to be negligible, and intimate contact will therefore be of no importance. It is a better rule, however, to be on the safe side, to provide good contact at all times.

THE FOCAL SPOT

Other factors being the same, the size of the focal spot of the X-ray tube (or of the radium salt in gamma-ray exposures) has a direct bearing on the sharpness of the shadow image formed. The smaller the focal spot, the better defined the image will be. The limitation to indefinitely small size is based on the necessity for dissipating the heat generated at the focal spot. Reduction of the power supplied to the X-ray tube would, of course, make it possible to use a very small focal spot, but, because of the economic need for obtaining a radiograph with a reasonably short exposure, a compromise must be reached between the time of exposure and the radiographic quality.

Given the practical situation where the best possible definition is desired with a given tube, the selection of focus-film distance has an important bearing on image sharpness. Simple analysis shows that the geometrical "unsharpness" $u=\frac{ft}{d-t}$, where f is the diameter of the focal spot, t is the distance of the point of interest from the film, and d is the focus-film distance. For practical purposes, t may be taken as the thickness of the specimen, because this is the maximum distance from the film where a void or flaw can exist. The space between specimen and film is assumed to be negligible. In this formula, u is the width of the fuzzy projected outline of the edge of a lead plate at distance t from the film (see Fig. 1).

Substitution of some reasonable values will illustrate the use of this formula. Assume a focal-spot diameter of $\frac{3}{8}$in., t=1in., and d=20in. The resultant unsharpness is 0·020in. Thus, from geometrical considerations alone, the fuzzy boundary of the image will be 0·020in. wide. It may be worse, because of the influence of other factors. Suppose we now change the focus-film distance to 40in. The unsharpness will decrease to 0·0096in., or about half as much as before. Continued increase in d will, of course, result in progressively smaller values of u, but a point will finally be reached where the eye cannot see any difference in the radiograph with increase in distance. Exposures will also become too long for economical operation. If $\frac{1}{2}$in. material is to be radiographed, instead of 1in. as assumed above, the unsharpness will be about one-half as great. It will continue to decrease with decreasing thickness, but changes will not be noticed by the eye beyond a certain point. Just where these changes become negligible will depend upon the type of film and screens used, as well as upon the sharpness of boundary of the detail being studied. Differences in geometrical unsharpness will not be as noticeable, in general, with intensifying-screen exposures as with lead-screen exposures, assuming the contrast to be the same in both cases, because so much unsharpness is caused by the intensifying screens themselves.

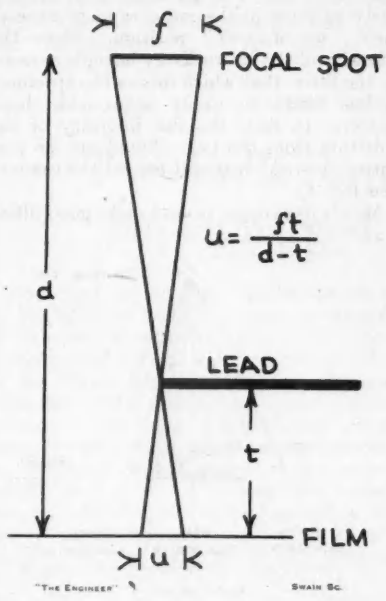


FIG. 1

The image of a spherical cavity in a casting can never be as sharp as the image of a hole of equal depth drilled in the direction of the rays because the change in metal thickness is much more abrupt in the latter. Thus, changes in focal-spot size or in focus-film distance will be more noticeable in the image of the drilled hole, since it forms a more critical test object. The image of the cavity is inherently diffuse in appearance, and therefore cannot be improved so much by adjustment of geometrical factors.

In most cases the thickness is small compared with the focus-film distance. The unsharpness formula may then be written $u=\frac{ft}{d}$ approximately. From this we find that, using the same focal-spot diameter, the geometrical unsharpness will be unchanged if the distance is adjusted so as to be directly proportional to the thickness of the specimen. Similarly, if several focal-spot diameters are available, the same geometrical unsharpness will be obtained with all if they are chosen to be inversely proportional to the material thickness, the focus-film distance being constant.

VARIABLE ILLUMINATION IN VIEWING

In the radiography of welded vessels or other structures in which the metal is practically uniform in thickness, it is common practice to use as low a kilovoltage as possible. This gives the maximum subject contrast and is most effective for the best rendition of detail. Under these conditions, the exposure may be adjusted so that the density in the resultant radiograph is suited to the brightness of the average illuminator. On the other hand, an irregular casting may have such high subject contrast that its radiograph shows a range of photographic densities which cannot be viewed properly at any one level of illumination. A high photographic density may contain as much detail as a low density, but the details are not seen, merely because the illuminator does not supply enough light to suit the human eye.

An X-ray illuminator capable of giving a medium and a high maximum brightness is a valuable accessory in any radiographic laboratory, to enable both average and high-density regions to be examined without difficulty. A further aid in the efficient

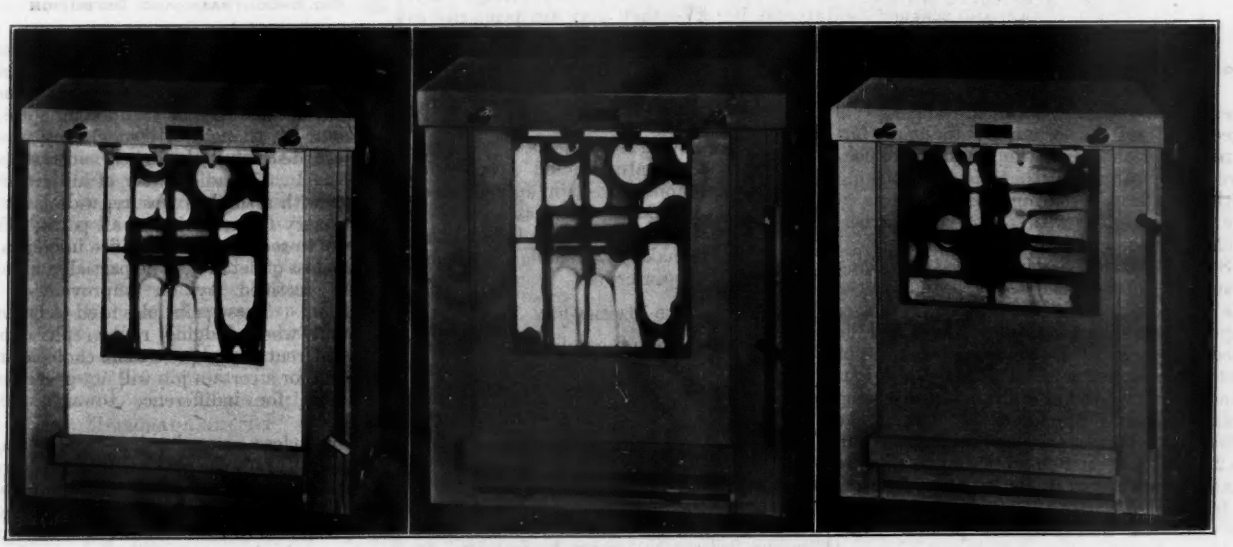


FIG. 2—"INDUSTREX" X-RAY ILLUMINATOR

examination of radiographs is the elimination of glare from the uncovered parts of the illuminated opal, which otherwise leads to an apparent reduction in contrast of the image in the centre of the opal. Both these features have been provided for in the "Industrex" X-ray illuminator, in which metal blinds are fitted to enable the maximum aperture of 17in. by 14in. to be reduced to 5in. by 4in. A "Photo-flood" lamp operated by a foot switch is fitted for the examination of the higher density regions in radiographs, the foot switch being so arranged that the lamp is switched on only whilst the switch is depressed, thereby lengthening the life of the "Photo-flood" lamp. This new illuminator is illustrated in Fig. 2.

It is worth keeping in mind that the eyes require a few minutes to accommodate themselves to any marked change in light intensity. Therefore, in order not to subject them to unnecessary extremes during the interpreting of radiographs, subdued general illumination should be provided in the viewing room itself. Subdued lighting is definitely preferable to bright lighting, or to no lighting at all, since it approaches more closely the degree of illumination transmitted through radiographs on the viewing equipment.

FILTRATION

Special illumination is not always an adequate provision for viewing the radiograph of high contrast. If the contrast is too high, some change must be made in the exposing technique. Of course, separate exposures may be made for the different

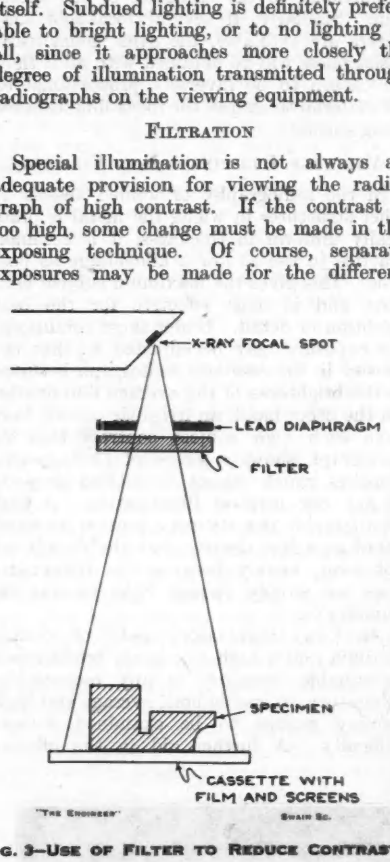


FIG. 3—USE OF FILTER TO REDUCE CONTRAST

thicknesses of the specimen, and this is excellent from the technical standpoint, but it may be both too laborious and too expensive. The same may be said for masking with sheet lead or barium clay, or filling in the thinner regions with a uniform absorber, such as fine copper shot.

Subject contrast may be reduced by placing a suitable filter in the X-ray beam as near the tube as possible (see Fig. 3). Longer exposure, or increased kilovoltage, will be needed to make up for the extra thickness of metal to be penetrated. This is not a serious handicap unless the machine is already being operated at its maximum capacity. The filtration technique has been investigated up to 220 kV, but there is no reason to suppose that this represents its limit of usefulness.

In order to clarify the function of a filter, let us assume that a certain specimen to be radiographed is composed of two principal thicknesses of steel, ½in. and ⅞in. When a satisfactory exposure is made for the ⅞in. part, the radiographic density is too high in the ½in. part. If ½in. of steel is introduced as a filter and the kilovoltage suitably increased, both thicknesses may be well rendered in the same radiograph. A certain loss of radiographic sensitivity is to be expected, because of the additional metal to be penetrated, but the loss is not as great as if the filter were a part of the specimen, because, being near the tube, very little of its secondary radiation can reach the film.

There are other advantages in having the filter near the tube. Only a small piece, which is convenient to handle, need be used. Small scratches or dents in the filter are not likely to show in the radiograph because of their "out-of-focus" position. Since the intensity of the entire X-ray beam is reduced by the filter, that which misses the specimen is less likely to excite appreciable back scatter. In fact, the full intensity of the radiation from the tube should not be permitted to strike material behind the cassette (see Fig. 4).

Metals like copper or lead make good filters

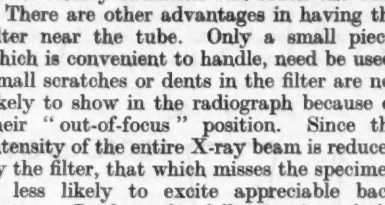


FIG. 4—EFFECT OF BACK SCATTER

because, for the same absorption, they are less bulky than aluminium or steel. The thickness of filter chosen will depend, of course, upon the total thickness and the thickness variation in the specimen. The situation is therefore too complex for formulating an exact rule. Since the filter thickness is not critical, satisfactory results may be obtained by classifying specimens so that a certain range of thicknesses may all be radiographed using the same filter.§

It was pointed out in the section on lead screens that they act as filters in addition to their other functions. At low voltage—say, around 100 kV—they may act primarily as filters, and to use additional filtration near the tube would almost certainly be too much. If, on the other hand, it were found better to omit the front lead screen, some radiographic improvement might be noted by using a filter having less absorption than this screen. The operator should keep a log book of techniques used in special cases, since the accumulated information will be of help in estimating factors in future work. Such a record makes a valuable supplement to the usual exposure chart.

X-RAY AND GAMMA-RAY FILMS

Recent progress in the radiographic inspection of industrial materials has been in two principal directions: first, the development of equipment which is convenient to use and which covers a wide range of radiation qualities; and second, the evolution of films to suit the various radiations and the more exacting requirements of modern radiography. By choosing the proper machine, radiographs may be made in the range from 5 kV to 1000 kV. Radium, as commonly supplied in its little "pill," furnishes us with an even shorter wavelength source.

There are two principal factors which determine the visibility of detail in a radiograph—contrast and definition. If two different metal thicknesses yield a large density difference in the radiograph, the contrast is said to be high; if the density difference is small, the contrast is low. Obviously, the technique which produces high contrast will give better clarity of detail than one which does not. The contrast characteristics of the film, time and temperature of development, kilovoltage, thickness of specimen, and amount of secondary radiation, are all factors which affect the contrast of the radiograph.

If the boundary between two areas of different densities is sharply defined, it will be more conspicuous than if that boundary shows a gradual change in density. The situation is similar to the improvement in detail in a photograph taken with the camera in focus as compared to one which is out of focus. It has been pointed out in the section on "The Focal Spot" that geometrical unsharpness affects the rendition of detail. The choice of film and screens is also very important.

It is apparent that to enable fine structures to stand out best, high contrast and a minimum unsharpness are both required. Little can be said about the net result of high contrast combined with a large unsharpness value or of low contrast combined with a small value of unsharpness, since the value

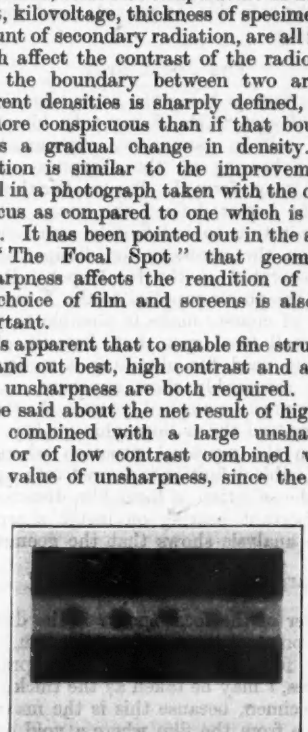


FIG. 5—CONTRAST AND DEFINITION

of high contrast may be partially or totally lost if accompanied by diffuse boundaries in the image. Similarly, if the unsharpness is small, details may be distinct, in spite of low contrast, though, of course, they would be more distinct with higher contrast (see Fig. 5). In the radiography of an irregular casting with a single exposure, wide latitude is necessary for rendition of all parts. This is likely to require some sacrifice in contrast, but the loss of detail may be partially or completely rectified by an improvement in definition. These principles need to be kept in mind when judging radiographs made with different techniques. The choice of the best film for a certain job will not necessarily make up for indifference towards other variables.

Upon close examination, X-ray and gamma-ray radiographs made with direct radiation (or with lead screens) show a certain amount of graininess. This is usually more conspicuous in the faster films. For the same contrast, the less grainy films show greater detail. Thus, graininess may be classed as

§ The interested reader is referred to the author's article, "The Reduction of Secondary Radiation and of Excessive Radiographic Contrast by Filtration," Proceedings of the American Society for Testing Materials, 40, 1940, pages 1189 to 1206.

one of the factors in definition, and should be so considered when planning a technique. A slow film speed, and generally a high contrast, are associated with fine grain. If the exposure time were of no consequence, such a film would almost completely displace all others. A contrasty, fine-grain film may be used with a higher kilovoltage than films of lesser contrast, to secure the same resultant contrast in the radiograph, and with the improved definition provided by such a film, an even lower radiographic contrast, produced by a further increase in kilovoltage, is permissible. The greater X-ray output arising from the higher kilovoltage helps to offset the slower speed of the film.

A given film shows increasing graininess with increasing hardness of radiation. This effect is not noticeable for small changes in kilovoltage, such as minor adjustments to change the penetration where the approximately correct kilovoltage is established. A similar effect is found with tungstate intensifying screens, but in this case the film is simply recording the characteristics of the screen, whose light is almost exclusively responsible for the exposure. Screen graininess is usually coarser and more diffuse in appearance than film graininess. In general, a fine-grain, high-contrast film (direct exposure type) is to be preferred for exacting work, and the coarse-grain film, or one for use with intensifying screens, left for the cases where thick materials are to be examined, requiring the fastest radiographic recording medium.

By way of illustration, consider the choice of materials for the radiography of 2in. steel plate. If the maximum kilovoltage available is 220, screen-type film will be used with tungstate screens. The actual kilovoltage used, however, will be adjusted to the lowest value consistent with a reasonable time of exposure. A direct-exposure type film with lead screens would be used at 300 kV. The slower, fine-grain type is preferable from the standpoint of quality, and continues to be all the way up through the 1000-kV region to gamma-rays. This type is recommended for gamma-ray work when overnight exposures can be made, but if only two or three hours can be spared, the faster type must be used.

The great bulk of magnesium and aluminium work is done at such low kilovoltages that the limit of the machine is seldom reached, even if a slightly higher kilovoltage is used to offset the slow speed of a fine-grain film. Screen-type film, when exposed to direct X-rays (with or without lead screens), usually has a low contrast and intermediate graininess and speed. Its application in this manner is quite limited, and it is supplanted by the higher contrast films.

The simultaneous exposure of two films, superimposed in the cassette, permits a shortening of exposure time and has the additional advantage of increasing contrast when the two radiographs are viewed superposed. If lead screens are used, a third sheet of lead unmounted would be sandwiched between the two films. This procedure is equivalent to increasing the latitude of the film, since high densities corresponding to thinner metal may be viewed in the single films and low densities representing thick sections may be viewed with the films superposed.

MICRORADIOGRAPHY

Microradiography differs from ordinary radiography primarily in the fact that it is customary to enlarge the radiographs in order to study the fine structure of the specimen. For enlargements of 50 or 100 diameters, special fine-grain emulsions are essential. These have a much lower X-ray speed than the emulsions commonly used in the radiography of materials. Successful commercial applications of the microradiographic procedure have been in such unrelated fields as studying the cemented joint in corrugated cardboard and distinguishing between natural and cultured pearls. Of particular interest to the metallurgist is the fact that enlargements of low-voltage radiographs of thin specimens of an alloy are capable of disclosing the difference in absorption of segregated constituents.

The general procedure is to prepare a specimen of the metal by grinding it down to a few thousandths of an inch in thickness. It is then mounted close to or in contact with a special fine-grain photographic plate and radiographed. The X-ray tube voltage chosen is likely to be in the range from 5000 to 20,000 volts. Trials will be necessary to find out just what radiation quality is best suited to a given kind of material. It may be desirable to select a particular target material for the X-ray tube in order to match the radiation with the absorption characteristics of the alloy to best advantage. Whether the continuous spectrum from one target at a certain voltage is better than the line emission spectrum from another is a point on which complete agreement is lacking. Certain it is, however, that attention must be paid to the choice of radiation quality for best results to be obtained. After processing, the radiograph is enlarged by ordinary optical projection or viewed through a low-power microscope.

The Rolls-Royce "Merlin 61" Supercharged Fighter Engine

LAST week we accepted the invitation of Rolls-Royce, Ltd., to inspect an example of the firm's new "Merlin 61" supercharged aero-engine, which is being fitted by the Royal Air Force to the improved "Spitfire" now operating with Fighter Command. By using a double-stage supercharger, with a water-cooled passage between the first and second stages of the supercharger and a cooler between the supercharger outlet and the induction pipe to the rear cylinder, it is found possible with the new engine to develop double the power output, as compared with that of the "Merlin III," the first engine to be fitted to the "Spitfire" fighters. When operating at a height of 40,000ft., the charge of air and fuel is now raised by the supercharger to six times the pressure of the surrounding atmosphere. Accompanying this article we reproduce engravings showing the end and side views of the new engine, along with a diagrammatic drawing giving a section through the supercharger and illustrating the arrangement of the cooling system.

Engine Particulars

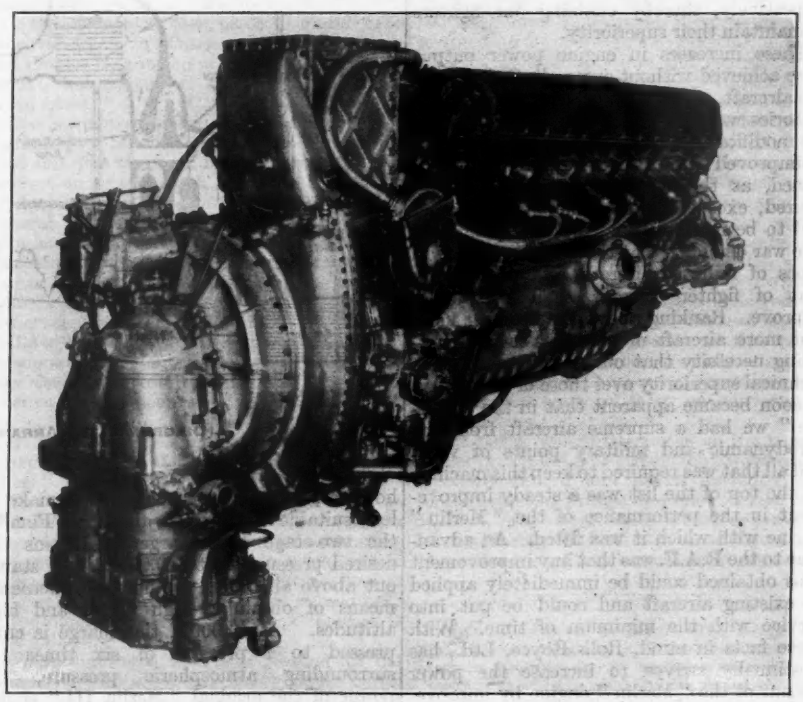
Number of cylinders	Twelve, in two banks of six
Cylinder bore	5·40in.
Piston stroke	6·00in.
Compression ratio	6·0 to 1
Total capacity	1647 cubic inches, or 27 litres
Cooling medium	Water under pressure, with 30 per cent. "Glycol"
Net weight of dry engine (estimated)	1600 lb. plus 2½ per cent.

Reduction Gear

Type of gear	Direct spur
Ratio	0·42 to 1
Direction of rotation	Airscrew, right-hand; engine, left-hand

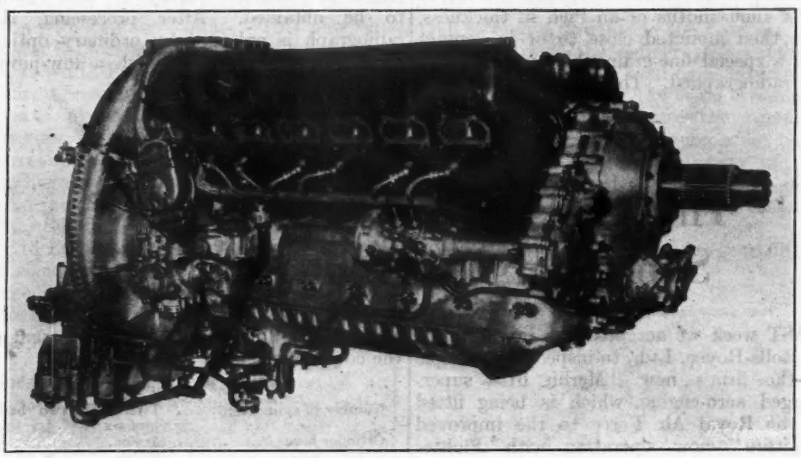
PROGRESS IN FIGHTER ENGINE DESIGN

It may be recalled that at the beginning of the war and during the Battle of Britain every R.A.F. first-line fighter aircraft was fitted with a Rolls-Royce "Merlin III" engine, and the complete defeat of the



ARRANGEMENT OF SUPERCHARGER OF "MERLIN 61" ENGINE

Luftwaffe in August and September, 1940, definitely established the technical superiority of British machines. The superiority was not obtained by chance, but every move of the enemy had been anticipated and a definite counter-move worked out. Early in the war, German aircraft resorted to low-flying tactics, and in order to counter this, Rolls-Royce immediately increased the sea-level power of the "Merlin" engine by 40 per cent. by raising the supercharger pressure. This move so improved the performance of the "Spitfire" at low altitude that German aircraft were forced to fly higher, and throughout the Battle of Britain there was a noticeable tendency for the German "ME.109s" to go higher and higher into the substratosphere, in order to try to escape from our fighters. It seemed at this stage that the German aircraft had an advantage owing to their smaller dimensions and lighter weight, but fortunately Rolls-Royce had ready for production a new supercharger, giving more power at high altitudes, and were able to introduce the "Merlin 45" and "Merlin XX" engines into the "Spitfire" and "Hurricane" classes of fighter respectively, thereby enabling our fighters to maintain their superiority.

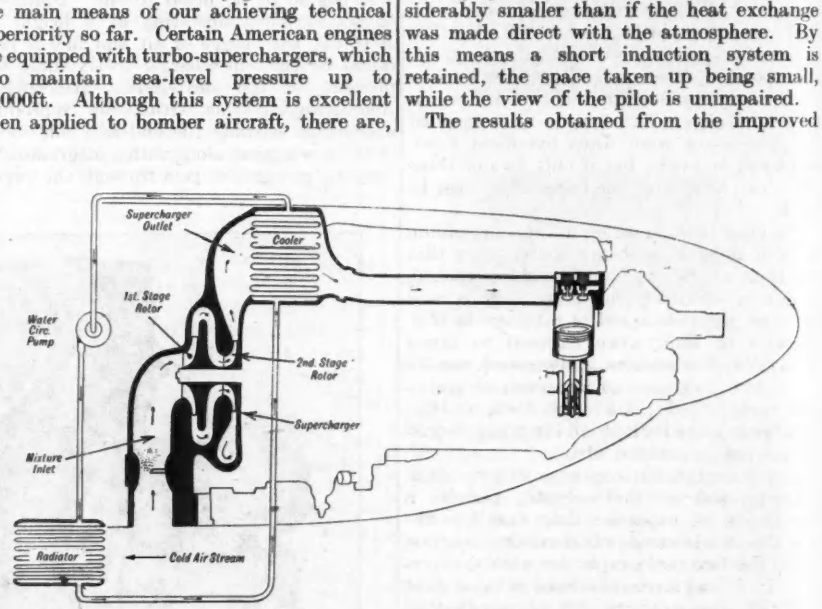


SIDE VIEW OF "MERLIN 61" ENGINE

These increases in engine power output were achieved without any radical change to the aircraft, and the flow of fighters from our factories was not affected in the slightest by the modifications made. A continuous supply of improved fighters to the R.A.F. was maintained, as the basic engine remained unaltered, excepting that a new supercharger had to be manufactured in large quantities. The war demands that the performance of all types of military aircraft, and particularly that of fighter aircraft, shall continually improve. Ranking above the need for more and more aircraft of all types is the overriding necessity that our aircraft shall have technical superiority over those of the enemy. It soon became apparent that in the "Spitfire" we had a supreme aircraft from the aerodynamic and military points of view, and all that was required to keep this machine on the top of the list was a steady improvement in the performance of the "Merlin" engine with which it was fitted. An advantage to the R.A.F. was that any improvement thus obtained could be immediately applied to existing aircraft and could be put into service with the minimum of time. With these facts in mind, Rolls-Royce, Ltd., has continually striven to increase the power output of the "Merlin" engine by improvement to the supercharger and carburetter, a logical development being the "Merlin 61," with two-stage supercharger and cooler.

The advantages of the system may be effectively reviewed by comparing the aero-engines which power the various first-line aircraft to the nations engaged in the war. German engines, without exception, are fitted with a single-stage supercharger, designed to maintain ground level pressure in the engine induction system up to a height of 20,000ft.

Rolls-Royce engines, equipped with single-stage superchargers designed to maintain the same pressure up to 30,000ft., and with supercharger rotors running at speeds up to 28,000ft., have been made, and the increase in altitude thereby gained has been the main means of our achieving technical superiority so far. Certain American engines are equipped with turbo-superchargers, which also maintain sea-level pressure up to 30,000ft. Although this system is excellent when applied to bomber aircraft, there are, however, technical reasons which make it less suitable for fighter aircraft. Finally, the two-stage supercharger maintains the desired pressure up to 40,000ft., and stands out above all others as the most successful means of obtaining high power and high altitudes. At 40,000ft. the charge is compressed to a pressure of six times the surrounding atmospheric pressure, the power of the original "Merlin III" engine being doubled, while at a height of 20,000ft. the output of the new engine is 50 per cent. larger than that of the original "Merlin III."



DIAGRAMMATIC ARRANGEMENT OF SUPERCHARGER

SUPERCHARGER DESIGN AND ARRANGEMENT

It will be seen from the accompanying drawing that the two-speed, two-stage supercharger has two rotors mounted on a common shaft, the arrangement being two superchargers in series. The mixture of air and petrol drawn through the carburetter is compressed by the first-stage supercharger, and it then passes through a cooled passage to the inlet of the second-stage supercharger, in which its pressure is again raised. After passing through a cooler, which is supplied from an air-cooled radiator, the mixture is delivered to the main induction pipe, which feeds the twelve cylinders, grouped in vee formation in two banks of six. The cooling of the mixture as it is delivered from the outlet of the second stage is effected in the square box-like structure containing the cooler elements, which is mounted between the rear of the cylinder blocks and the supercharger casing. As previously mentioned, in addition to the main cooler there is a water-jacketed passage between the two supercharger stages, which contributes to the cooling of the charge. The supercharger cooling system is entirely separate from that of the engine, and the radiator for cooling the circulating fluid and dissipating the heat abstracted from the compressed charge can be placed in any convenient position in the aircraft.

In the "Spitfire" it is mounted under the wing of the machine in a duct which also contains one of the main engine cooling radiators. The other engine cooling radiator is placed in a similar position on the opposite wing, and alongside it is arranged the engine oil cooler. An advantage of the liquid cooling system is that it can be made considerably smaller than if the heat exchange was made direct with the atmosphere. By this means a short induction system is retained, the space taken up being small, while the view of the pilot is unimpaired.

The results obtained from the improved "Spitfire" powered with the new engine we have described have, we learn, more than fulfilled the hopes and expectations of all who have helped in the work. Every aspect of this wonderful fighter aircraft has been tremendously improved by the introduction of the "Merlin 61." This outstanding development of an already fine engine should do much to counteract the tendency there sometimes is in this country to belittle the qualities of our military equipment and to

BALTIMORE AND OHIO RAILROAD OIL ELECTRIC FREIGHT LOCOMOTIVE

exaggerate the good points of our adversaries' equipment. The completion and entry into service of the "Merlin 61" is a proof, if such were needed, that we are in no way lagging behind, either in the matter of technical development or in the speed with which new ideas are put into service. The advent of the new German "Focke-Wulf 190" on the battle front, with its 1600 H.P. air-cooled supercharged engine (see THE ENGINEER for August 14th), caused some uninformed persons to believe that the Germans had stolen a march on us in the high-performance fighter class of aircraft, but, as enemy fighter losses continually show, the improved "Spitfire" with its new "Merlin 61" engine was there to surpass it.

B. and O. Railroad Oil Freight Locomotive

THE Baltimore and Ohio Railroad Company's main line oil freight locomotive "No. 1" made its initial run from Chicago to the eastern seaboard of the United States by pulling one of the heaviest through rail shipments of petroleum on record. The solid train of tank wagons left Chicago on the morning of August 1st bound for a distribution depôt at Twin Oakes, near Philadelphia, Pa.

The train had a deadweight of 5300 gross tons, and the locomotive pulling it was built by the Electro-Motive Corporation. This freight locomotive of 5400 H.P. provides the first instance of such a unit being operated in regular freight service on any railway in America. The train was scheduled to make the run from Chicago to its destination without change of locomotives or the dropping of any of the loaded wagons. The run of 911 miles called for five stops at stated points for the customary crew changes and for inspection, and it was necessary only at two of the stopping points to refuel the locomotive on that epoch-making trip.

Previous test runs of the locomotive, when drawing heavy-tonnage trains, indicated that on this especially long run the locomotive would be able to haul about 175 times the volume of oil consumed by its engines. As the 911-mile run was, in effect, also a test run, Baltimore and Ohio engineers were desirous of obtaining accurate data regarding the unit's performance on this unusual operation, and to that end a dynamometer car was attached just behind the locomotive to furnish a check on the functioning of "No. 1."

Because the engine was new, and also for other reasons, no attempt was made to establish a speed record. Instead, the aim was to maintain an average speed for the entire run of about 20 miles an hour. In fact, the train made 23·4 miles an hour, and it stopped at certain of the terminals or stations for as long as two hours. According to a representative of the Baltimore and Ohio Railroad Company, "The run showed the advantage of diesel power in a number of ways, overall, for the excellent hauling job of a heavy-tonnage train; high availability in making the entire run on which, had steam engines been used, it would have been necessary to change engines five times; and despite long terminal delays, good average speed was achieved because of quick acceleration."

The locomotive illustrated herewith is one of a group built for the Baltimore and Ohio Railroad and, like the main line oil passenger locomotives on certain crack B. and O. trains, is a product of the Electro-Motive Division of General Motors, at the La Grange, Ill., plant. It measures 193ft. from its streamlined head to its rear coupler, and is composed of four short power wagons, each containing a sixteen-cylinder General Motors, two-cycle C.I. engine, conservatively rated at 1350 H.P. The crankshafts of each of these four engines, with a total horsepower of 5400, are connected directly to four electric generators, which feed power into traction motors mounted on the trucks. There are sixteen traction motors, each of which is geared to two wheels, making every one of the thirty-two wheels of the locomotive a "power wheel."

The locomotive can pull a freight train at 70 miles an hour, as compared with a maximum speed of 120 miles an hour for its sister main line passenger locomotive, but in actual freight train operation a speed of 70 miles an hour is not required nor attained. Water is used only in the radiators. The fuel oil tank capacity is 4800 gallons.

We are informed that it is possible for the locomotive to start a long heavy train—either on the level or on an upgradient—and to get the train up to a balanced speed in less time and within a shorter distance than are required by the most powerful steam locomotive in doing the same job under identical conditions.

A novel feature of the new locomotive is its electric braking system. Electric retarding brakes have been used on some of the older types of electric locomotives, which draw their current from power lines through trollies or third rails, but it is a new feature on independent oil-engined freight locomotives. By simply reversing the fields of the locomotive's sixteen traction motors they become generators. The electric current, so generated, is fed into grids on the roof of the locomotive power units and is dissipated in the form of heat.

The operating crew's compartment is similar to that of the oil passenger locomotive. All control levers are easily accessible and, with the exception of one lever that controls the traction motor connections, they are identical to the controls of a steam locomotive, namely, throttle, reverse bar, train and locomotive air brakes, sander, bell valve, and whistle cords. Therefore it is simple for an engineer to switch over from steam to oil after only a few hours' of instruction.

An instrument board, similar to an automobile dashboard, has indicators which show track speed, air brake pressures, wheel slip, and train control indications. Back in the engine-rooms are indicators that signal engine trouble and hot journal bearings. Automatic windshield wipers and defroster slot are provided. Adequate ventilation in the cab is assured by roll-down side windows, and the cab can be heated in cold weather merely by throwing a switch. The rear wall and roof of the cab are soundproof against train and engine noises, thus enabling the crew to carry on conversation without raising their voices.

The power wagon framing is on the trussed bridge principle. The streamlined front end is especially braced and has a battering ram conformation to protect the crew in case of a collision. The crew's safety is further provided for by placing the cab high in the nose and above and behind any normal point of impact.

RAILWAY CHANGES IN INDIA.—The Bengal and North-Western Railway and the Rohilkund and Kumaon Railway are to be taken over by the Government of India, and will be amalgamated as from January 1st, 1943, after which they will be known as the Oudh and Tirhut Railway.

The "Auto-Railer"

AMERICAN ordnance plants are now using a new "Auto-Railer," built by Evans Products, of Detroit. The "Auto-Railer" is a train which runs on rails or on the highway, and consists of a locomotive and two double-ended trailers. It operates on forty-two rubber tyres and the changeover from rail to road working takes no more than a few moments. Steel flanged wheels are employed to hold the vehicles on the rails, and are retracted for operation on the road. The steel wheels act merely in the nature of guide or pilot wheels, with the rubber-tyred wheels taking approximately 80 per cent. of the load in rail operation and 100 per cent. on the highway. Raising and lowering of the guide wheels is accomplished by compressed air. The train is equipped with standard railway air brakes, controlled in the locomotive.

Each trailer is built with all-wheel steering, so that each of the tyres of the trailers rolls in the same path as the tyres on the locomotive, their movement being synchronised with the movement of the locomotive wheels. The steering is done through the tow bar.

A number of "Auto-Railer" units of various types—such as explosive trucks, ambulances, fire fighters, inspection cars, and other units—are already in national defence service. "Auto-Railer" lorries, buses, trailers, and locomotives have been employed in daily revenue service on the railways for the past seven years, and the adaptation of the "Auto-Railer" to the national emergency has solved a number of problems which required the utmost flexibility of transportation units.

The construction and design of the "Auto-Railer" follows that of automotive practice. The manufacturer claims that not only is the initial cost of the "Auto-Railer" low, but that the economy of operation is also lower than the operating cost of conventional railway equipment. It is considered by the makers as suitable for industrial work, switching, and branch-line operation. Though designed primarily for transportation of munitions, it also can be used for handling a great variety of other kinds of materials.

"AUTO-RAILER" ON ROAD AND RAIL

Less Paper—More Head and Foot Work*

THIS country (U.S.A.) has a capacity for producing steel, and a performance too, that is greater than all the rest of the world. It is inconceivable that if non-essential uses of this precious metal are curtailed, we should not have enough available for all war purposes.

Eighty million tons of steel or more a year is a lot of steel. Enough to build 240 first-class battleships—if we wanted them—or a merchant fleet of cargo ships four times the total tonnage of Great Britain's floating merchant marine empire.

Putting it all into "M-4" tanks, we could make 2,660,000 of them, enough tanks to stretch, end to end, nearly halfway around the globe at the Equator.

Putting this annual steel output of ours into 3in. shells would give us enough to fire one per second for the next 250 years.

Of course, we don't want it that way, but these comparisons will give you an idea of what our steel capacity and production amount to in terms of war material. Hitler would sell his soul to have it were that questionable asset of his not already sold to the devil.

With this tremendous and enviable capacity to produce, why is it that we are encountering shortages? Maybe it's because, in working out the channels of flow of the steel that we have, we are depending too much on paper work and too little on head and foot work.

That has happened plenty of times before in private industry, as most any practical production man can tell you.

One of the foremost of our past American "efficiency engineers" put a "system" some years ago into a Midwest manufacturing plant. Theoretically, the foundry, forge shop, machine shop, and other departments of this plant had sufficient capacity to meet all demands for parts for shipments. But deliveries were from three to six months behind and bottlenecks were a daily happening.

The expert installed dispatch boards, production slide rules, red tags, green tags, and white tags plus the most complete and elaborate system of paper forms that one could imagine. And deliveries got still further behind.

Then the practical-minded general manager organised a staff of "chasers." Trouble men who knew what things were about, who "lived" in the departments and who came "a-running" to the front office only when things went amiss and needed attention. Shortages and bottlenecks then began to evaporate together with slide rules and fancy forms, and delivery dates were met promptly.

Sometimes it's not what you've got that's not enough, but what you do with what you've got. And in such cases, head and foot work beats paper work all to pieces.

* By J. H. Van Deventer in *The Iron Age*, September 3rd, 1942.

The "Churchill" Tank

IN the House of Commons on Tuesday, December 15th, the Prime Minister, in reply to a question, made a statement concerning the work of the Tank Board and the development and production of the "Churchill" tank. Mr. Churchill said:—

On account of persistent mischievous attempts to undermine the confidence of the troops in these weapons, which play an important part in the defence of this island, I propose to make the following statement:—On June 11th, 1940, I summoned a meeting at which the following were present:—Sir James Grigg, Permanent Under-Secretary of State for War; Major-General L. Carr, Assistant Chief of the Imperial General Staff; Mr. (now Sir R.) Sinclair, Director-General of Army Requirements; Mr. Herbert Morrison, Minister of Supply; Mr. P. F. Bennett, Director-General of Tanks and Transport, Ministry of Supply; Sir Walter Layton, Director-General of Programmes, Ministry of Supply; Brigadier J. S. Crawford, Director of Mechanisation, Ministry of Supply.

The object of the meeting was to consider our tank production programme. We had at that time in the hands of the troops in the United Kingdom less than 100 tanks. These and those under production at the time were of a type which had been proved in battle in France to be too weak to stand up to the German tank guns. Invasion of this country was expected, if not in the autumn of 1940, at any rate in the spring of 1941 or even in 1942. The problem therefore was to produce the maximum number of tanks of a sufficiently powerful kind for home defence. As a result of the meeting, I called for a plan which would provide 500 or 600 such tanks, if possible, by March, 1941. These were to be over and above the existing programme and were not to interfere with it.

The same people met again on June 20th and considered a specification and preliminary production programme for the new heavy tank. I gave directions that the specification should be considered by the Tank Board, but that in the meanwhile all preparations for production should proceed. The Tank Board consisted at that time of the following:—Sir Alexander Roger (Chairman); Mr. Durrant (Chief Mechanical Engineer (Roads), London Passenger Transport Board, later Director of Tank Design); Mr. Moyses (Birmingham Railway Carriage and Wagon Company, Ltd.); Mr. Thompson (Secretary, Union of Shipbuilding and Engineering Draughtsmen); Mr. Geoffrey Burton (deputy chairman, Daimler Company and B.S.A., then newly appointed Director-General of Tanks and Transport, Ministry of Supply); Major-General J. S. Crawford (Director of Mechanisation, Ministry of Supply); Major-General Pope (Director of Armoured Fighting Vehicles, War Office); Brigadier Pratt (Commander of the First Army Tank Brigade). Major-General Pope, who was later, unhappily, killed in the Middle East, had been senior Royal Armoured Corps adviser to the Commander-in-Chief of the British Expeditionary Force in France, and Brigadier Pratt had commanded the First Army Tank Brigade

in France; thus both had up-to-date experience of the conditions of modern war. Action proceeded accordingly.

On July 20th we met again, Major-General Pope also being present. The Tank Board had approved the specifications, subject to certain modifications, and it was agreed to go forward with the utmost rapidity with the production of what became known as the "A 22" tank. The General Staff expressed themselves entirely in favour of the project. Work proceeded with the utmost enthusiasm. We could not afford the time to wait to carry out exhaustive trials with pilot models. This would have set us back at least six months. Our paramount aim was to get the maximum number we could into the hands of the troops in 1941. The pilot model was running on December 12th, 1940. Production began to flow in May, 1941, and by the autumn 400 were available for battle.

Meanwhile the German armies had been launched against Russia and the danger of invasion had lessened. The possibility of using the "A 22" tank in an oversea offensive *rôle* was therefore considered, and modifications were introduced to make the tank more suitable for extended operations abroad. That winter we began reworking these tanks, and large numbers are now in a fit condition for use in the assault of strong positions for which their armour fits them. Reports have been received from the brigades in this country now armed with these tanks which are on the whole strongly favourable. There are between 1000 and 2000 in the hands of troops. They are said to be the best weapons yet received by the units concerned.

It will be seen that this tank was never intended for the fast-moving long-range warfare of the desert. However, a certain number were sent to the Middle East in the autumn of 1941 for trial. It will interest the House to hear that a small number took part in the attack on Rommel's lines at Alamein, and reports show that they gave a good account of themselves and stood up to very heavy fire.

I am glad to have had this opportunity of informing the House of the history of this tank and of publishing the names of those who took the bold decision to introduce it. No one would go back on that decision now. The "A 22" is naturally surpassed by the latest types, but the production in large numbers in less than a year of an entirely new tank of much heavier pattern than anything we had before and thoroughly capable of going into action in home defence is highly creditable to the British engineering industry and to all concerned.

War Uses of Industrial Gases

THE Ministry of Supply points out that it is necessary to economise in the use of calcium carbide, both on the grounds of shipping and new war demands. Supplies, it is announced, will be maintained as far as possible to essential consumers, who are unable to effect any substitution. Such maintenance depends, however, on reducing the present consumption of calcium carbide in other directions. In the cutting of metals and in non-ferrous welding, it is pointed out that the actual gas used can be either acetylene, propane, or boosted coal gas, and by using the last two gases it will be possible to save many thousands of tons of imported carbide. Where possible, especially when installing new plant, electric welding should be adopted, more particularly in the case of light-gauge welding work. Propane is a by-product of petroleum refining, and sufficient supplies, it is stated, are available to meet all the purposes for which it could be substituted. These purposes cover all those for which acetylene is normally used, except for the welding of iron and steel. One 56 lb. cylinder of propane will, it is stated, do the same amount of work as three 200 cubic feet cylinders of dissolved acetylene. The use of propane will therefore produce economies not only in steel but in man-hours. When using propane care must be taken to effect a close adjustment of the mixture of the gas with oxygen, as the limits are finer than those when oxygen and dissolved acetylene are employed. When adjusted, however, the torch will not blow back, as acetylene sometimes does, and, in general, a narrow clean cut is made; indeed, propane is a better cutting agent than acetylene. Coal gas may be used for cutting operations and for certain kinds of non-ferrous welding. The amount of coal gas which would be needed for substitution on a large scale is available, and by its use there is an economy in cylinders, as the gas is generally piped round the works, and, where necessary, it can be pressure-boosted for hand cutting. In general, better results are obtained if coal gas is enriched with some other gas, such as propane, methane, ether, or acetylene. With regard to the private manufacture of acetylene, the Ministry of Supply advises firms which can do so to continue to make their own gas in preference to turning over to dissolved acetylene in bottles. There are many new demands for the making of new cylinders, and, where possible, it is desirable that existing gas-making equipment should be used and not scrapped. Should a case arise, however, in which circumstances make it necessary to switch over to gas in cylinders, the facts should be reported to the Raw Materials Department of the Ministry of Supply at Warwick.

Use of Man-Power in Aircraft Factories

IT was announced on Monday, December 14th, that the Minister of Aircraft Production had appointed a new board to investigate and advise the Department upon the measures necessary to effect a more economical use of man and woman power in aircraft factories. It will consist of Sir Charles Bruce-Gardner, M.I. Mech. E., as Chairman, Mr. Frank Chappell (for twenty years an officer of the Amalgamated Engineering Union), and Miss A. G. Shaw (the chief supervisor of women at Metropolitan-Vickers Electrical Company, Ltd., Manchester). The scope of the inquiries to be made will cover all aspects of the use which is being made of labour and plant in aircraft factories, including the output, working conditions, and hours of work from the efficiency point of view. The Board will consult with the Joint Production Committees and other advisory bodies and will thus enlist the interest and assistance of managements, workers, and technicians.

American Engineering News

Emergency Specifications

Under conditions resulting from the war it becomes necessary or desirable to modify many standard specifications for materials, and engineering societies in the United States have been prompt to take action. To avoid the delays in approval of specification revision at annual meetings, the American Railway Engineering Association has a special emergency committee and a new regulation under which modifications may be adopted temporarily by the various committees. These emergency specifications are issued on yellow paper in order to be significant. For example, alloy steel bolts for rail joints are not to be supplied; copper content steel is not to be used in spikes and tie plates, gaskets and packing are not to be of rubber, and flexible tubing is to be used instead of copper for gasolene—or petrol—on railway motor-cars. The American Society for Testing Materials also has issued a number of emergency specifications. Its five specifications for cement have been reduced to three, and the twenty-eight-day test reduced to a three-day and seven-day tension test. Of some fifty emergency alternative specifications that can be put into use in minimum time, nearly half relate to steel and steel alloys for ordnance and aircraft use. Copper has been practically eliminated from all steels, owing to its scarcity, and manganese is being limited in the less essential steels to conserve it for war materials, where it may take the place of nickel and chromium. Stainless steel is replacing aluminium to an increasing extent in aircraft. Other emergency specifications cover electrodes for gas and electric welding, and for steel pipe to be used as piles, also Bessemer cast steel, and asphaltic felt for roofing purposes. A new test for asphalt softening point is made in ten minutes, as compared with ninety minutes for the ordinary standard tests. All this emergency revision work is undertaken in co-operation with the War Production Board.

Army Specialist Corps

An innovation in the United States Army is the establishment of the Army Specialist Corps as an adjunct to the specifically military sections of the organisation. As explained in a recent report, there are many auxiliary functions, such as those relating to the procuring, testing, warehousing, and transportation of materials and supplies, and to their delivery in proper quality and quantity as and when needed by the combat troops. Thus one of the principal duties of the new Corps will be to secure competent men from civil occupations to perform services which otherwise would have to be handled by professional military officers. The officers will not require military training in the handling of troops, will not carry arms, and will only exercise command of troops when these are assigned to aid them in the performance of non-combatant duties. The Corps is organised to furnish engineer and supply officers, research officers, statisticians, ordnance and quartermaster personnel, public relations officers, communications officers, accountants, and many technical positions in motorised units and air units. The supply will be drawn from lists of applicants, files of the national committee on scientific and specialised control, and also by calling on engineering societies, business organisations and colleges. Many of these men will have to be trained for specific lines of work. Electrical engineers and physicists are particularly needed, and may be trained from men who have had one or two years of college work, or those who have had to leave college before completing a full engineering course. Final selection is made after a personal interview, but very complete record is required as to physical conditions as well as technical qualifications, since these men may have to serve with troops under various conditions of climate and country.

Bituminous Coal Research

Research in the bituminous coal industry of the United States, begun shortly before the war for the purpose of effecting a wider and more economic use of this coal, is developing new equipment and methods for more effectively meeting the needs of house heating, metallurgical work, locomotives, and power generation. Enclosed stoves for rooms and furnaces for house heating have been devised which give complete combustion without smoke, and thus meet the smoke prevention requirements of municipal regulations. Another result is the use of coals within a wide range of specifications, instead of limiting particular kinds to specific purposes. Industrial furnaces, small and large, are under study, and in metallurgical processes pulverised coal is found to heat steel satisfactorily and with a minimum of scale. However, for commercial use the heat regenerators must be redesigned so that they will handle the ash. While gas and oil have largely replaced coal in forging, present conditions have led to its use in a small type of forge ordinarily fired with gas. A radiant tube furnace has been devised for heating wares that must not come in contact with flame. Of a thousand locomotives now under order, only about half are to be steam driven, but plans have been made for a coal-burning engine able to use the smaller sizes of coal with a minimum loss of ash or cinders at the funnel. Under war restrictions of gas and oil, bituminous coal is being used increasingly for house heating furnaces, and may be used permanently if satisfactory to consumers. Petroleum products are in use for treating coal in storage, particularly for allaying dust, but as these may be prohibited, experiments are being made with calcium chloride and other materials to keep the surface of the coal moist and free from dust.

The Engineer

DECEMBER 18, 1942

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NOTICES TO READERS

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this paper or described in its editorial columns should not be taken as an indication that they are necessarily available for export.

With a view to the conservation of paper, readers are advised, in the interests of all concerned, to place a regular order for THE ENGINEER with their newsagent or direct with the Publisher.

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CHANGES OF ADDRESS

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THE DOCTRINE OF MOST WORK

HARD as it was for people brought up on the practice and traditions of the old masters to understand the futurists or post-futurists, and cubists and the vorticist, *et hoc genus omnes*, it is perhaps not less difficult for those who learnt from their fathers and mothers the simple principles of classical economics to keep pace with the headlong heterodoxy of a school of thought which impatiently sweeps aside all the articles of faith that had been accumulated in thousands of years, and were often embalmed in household saws and maxims. To the old school, economics was not merely the science of prudent management; it was an ethical, almost a moral, code. To our grandfathers and fathers, thrift and self-reliance were virtues, and charity was a divine ordinance. Money was money; solid coin that the miser could hoard in his strong-box, the Chancellor accumulate in his war-chest, and the old wife tuck away in a stocking. It was something positive and substantial; not a nebulous immaterial thing like credit, and not something that one could treat cavalierly as a mere book-entry. Since the traditional economic principle has been built up and absorbed through thousands of years, it is not surprising that entirely new principles are regarded with suspicion and distrust or total incomprehension. That they represent a sincere endeavour to accommodate economics to new conditions cannot be denied, even by those who are most opposed to them, and it is probable that, just as in art the exaggerated methods of the revolutionaries have left some effects, whilst they themselves are beginning to pass, some feature of the new economics will in time become grafted upon or blended with the old.

One of the most firmly established of the so-called laws of economics was that of supply and demand. That law implies not only that supply will vary as the demand varies, but that the prudent producer will endeavour to estimate in advance what the demand in an approaching period will be, and to lay his plans accordingly. In present-day jargon, supply should be evaluated to demand. Until quite recently it was accepted as a sound business axiom that no one should produce more than he could sell. But that does not suit the book of the New Economists, and they have therefore turned the old doctrine inside out. No longer, they say, must we equate supply to demand; we must do just the reverse and equate demand to supply. That leads to what we venture to call the Doctrine of Most Work. The object of the revised formula is to give as much work as possible, so that unemployment may never riss above an inescapable minimum—estimated at 8 per cent. by Sir William Beveridge. It embraces the belief that if only people can be kept at work they will consume all that they can produce, but requires, obviously, that the amount of money circulated in the form of wages and salaries, and interest (if any is permitted), will always be enough just at least to balance the cost of production. But since that essential condition may not always be satisfied, one economic school advances the proposal that the Government should "print" new money whenever the economic circumstances seem to justify it—as in public works—or to require it. To discuss all the ramifications which this reversal of an old "law" involve would require the reprinting of one or more of the pamphlets or books which have been written to advocate and elucidate it. The kernel of the whole thing is, keep everybody at work by hook or by crook, and they will consume all that they produce. Briefly, give unlimited work and an unlimited market will follow.

It is not surprising that ideas so revolutionary should be met by much opposition. The older economists do not believe that unemployment and want can be eradicated by a practice which flies in the face of prudent management. They hold that the printing of more money—Mint Sauce, as they flippantly call it—would lead inevitably to the devaluation of the pound—to inflation—and that the productive capacity of the world is so enormous that the markets would be saturated before the total supply could be absorbed. The weakness of their position is that they have no alternative to offer for the existing methods. They rightly say that hitherto markets have followed increasing production and that improved methods of manufacture have invariably led automatically to greater employment. They believe that the same thing will hold in the future and that the mass unemployment of recent years is a passing phase; but they have no plan for assuring that desired end, and at the moment the world demands plans. The old story repeats itself; the innovator has something to offer; he can attack, whilst the conservative is always of necessity on the defensive.

Allied Steel Pool

THE announcement of the setting up of a Committee to unify the "steel productive facilities and the munitions-making facilities of the United States, Great Britain, and Canada" into a "single unit" (see page 491) is a logical step in the organisation of the industrial strength of the three nations in the war effort. It will be said, probably, that it is a move that should have been made long before the fourth year of the war, but that would ignore the enormous amount of work in organising the resources of the United States and the British Empire which has already been done. The creation of the Committee is the result of work which has been going on incessantly in the background for a long time, and when circumstances were ripe the important step was taken, and the steel industries of three great nations already tuned up by the hard experiences of war, fell into the position of being, to all intents and purposes, a single industry with a single object. The official notice issued by the Combined Production Resources Board and the Combined Raw Materials Board puts the object of the Committee these bodies have appointed as being "to squeeze every possible ton of steel out of existing plant facilities in order to fulfil the combined war programme for 1943," in order that "the maximum impact of weapons of war can be brought against the enemy in 1943." Not long ago a United States Steel Mission visited Great Britain, and, as a result of the investigations then carried out, concrete differences in the production and use of steel in the United States and Great Britain were discovered. The Mission recommended that better results could be obtained in both countries by pooling technical information, production, and distribution methods.

In the process of organising industry in the war effort, important bodies have been set up on both sides of the Atlantic. Amongst them is the Combined Raw Materials Board, which for a long time has sat at Washington. This body includes representatives of all the Allied Nations and one of its chief duties is to allocate to the Allies supplies of war materials. For instance, recently it was announced that the greater part of the production of tin in the Congo would be allo-

cated to the United States, whilst Great Britain had been allocated ore from Nigeria, South Africa, and other areas. It may be assumed that the new Committee will have similar directive powers over the production of steel in the three countries mentioned, and it is probable that even before the public announcement, work on the part of its task referred to in Instruction 5 had been in progress. It will be remembered that a short time ago it was stated that Great Britain would concentrate to a larger extent on the production of locomotives, and the United States to a greater degree upon the production of certain classes of armaments. The Combined Production and Resources Board has also been in operation for some time, and is formed of representatives of the United States and Great Britain, and, in effect, supervises the production of war materials in both countries. The experiences gained during the war have shown the necessity of "assembling and co-ordinating information on such important raw materials as iron ore, scrap," and other materials needed in the production of steel. In fact, each of the instructions given to the Committee deals with a matter of primary importance to the steel industries, not least being the one designed to facilitate the exchange of technical information. Some idea of the importance of the Committee's duties can be gathered from the available figures of the steel production in the United States, Great Britain, and Canada. In 1941 the United States produced 83 million tons of steel, and it was expected that this would be further increased to 88½ million tons. The British production can only be estimated on the 1937 figures, which give 13 million tons of steel. This total has probably been increased substantially, whilst the Canadian production of steel was recently estimated at 2,200,000 tons per annum. These figures give the steel production of the three countries which the Committee has to unify at well over 100 million tons per annum.

Some surprise may be expressed that other Empire countries have not been brought under the supervision of the new Committee, but it is probable that if only for geographical reasons and for reasons concerning the magnitude of the production, it was decided that, to begin with, the Committee would have its hands full in obtaining the desired results from three countries. There is already in existence a system of Empire collaboration in steel and munitions production, known as the Empire Clearing House, which sits in London, and whilst as a result of the knowledge and information gained by the operations of the Committee it may be decided later by the United States and the Empire to extend the scope of the new Committee's work, it is probably felt that for the time being it is wiser to limit the principles of unification to those countries in closest conjunction in a technical as well as a geographical sense. The appointment of the Committee is the indication, if one were needed, of the determination felt on both sides of the Atlantic to exert every possible force for the destruction of the Axis and the mere fact that technical information —no doubt some of it of a valuable character —is to be surrendered for the public benefit, shows that nothing is to be allowed to stand in the way of achieving the objects which the Committee has been appointed to attain.

Literature

The Theory and Practice of Heat Engines. By D. A. WRANGHAM, Wh.Sc., M.Sc. London: Cambridge University Press. Price 50s. net.

The Theory and Practice of Heat Engines. By R. H. GRUNDY, Ph.D., M.Eng. London: Longmans, Green and Co. Price 18s. net.

ABOUT a hundred years ago engineering became a subject for study in its own right. Till then physical science was studied in the universities for the most part only for study's sake, and people who, like James Watt, were interested in natural phenomena in plying their art of "directing the great sources of power in Nature for the use and convenience of man" were not generally welcomed to the company of scholars. Yet the aspiring engineer had to search for light and leading in the diverse works of a few accepted authorities. Engineering needed a codification of its studies, and this was first done at Glasgow by Macquorn Rankine in his pioneering text-books. It was in 1861 that his "Steam Engine and Other Prime Movers" was published, and a not inconsiderable proportion of that work has appeared in every text-book written since then on the subject of heat engines. Ewing's volume on the steam engine, published in 1894, is perhaps an exception, but it was distinguished in that, although not an examination maker's guide, it was at once an authoritative technical work and a piece of English literature. The writers of text-books seldom possess Ewing's authority or his readability, and where they use the work of others to support them, as they strain beyond their own limited reach, they not unseldom choose the most faulty props.

The writers of text-books are naturally best acquainted with the elementary parts of their subject; for they have, as students, mastered them with more or less pain and labour. They must therefore again present it all to the reader, although it has been done innumerable times before. What a saving of time and material and expense there might have been had authors of text-books been content only to put into their work what others had not previously done quite as well.

This applies with special force where the publication is an expensive one. The buyer of a fifty-shilling book expects to find that it carries its subject to an advanced stage; he expects that it is authoritative and accurate.

The publishers of Mr. Wrangham's book claim that it is "a comprehensive text-book for engineering and mining students reading for an honours degree." This claim is of doubtful validity. Although it could not be said that a student equipped only with the knowledge contained in this work would be unable to pass any honours examination in heat engines, yet the honours student may reasonably be expected to know a great deal more about specific aspects of the subject than he will find in it.

Take, for example, the section on the Flow of Heat, which contains in all about twenty-three pages. The majority of these pages are devoted to the deducing of conduction formulæ of secondary importance and to establishing the Grashof (here called Gashof) expression for temperature difference. A page disposes of the dimensional method of analysis and the "Reynold (*sic*) number." Although the design of surface condensers might well be regarded as an application of the principles of heat transfer, there is nothing on that subject to suggest that it is.

Three chapters are given over to the subject of the internal combustion engine, but the reader will find in them little that is not in cheaper books. An honours student in any college of standing would be expected to know a good deal about the thermodynamic analysis of engine cycles by calculative and graphical methods, involving the application of known expressions for the variable specific heats of gases and the entropy characteristics. But there is little of that in this volume. There is a haziness about some of the discussion of the ignition process; but in dealing with combustion in the compression-ignition engine Mr. Wrangham lays himself open to serious criticism in implying, as he does, that ignition of the oil awaits a considerable degree of vaporisation. A book of honours standard should not neglect an adequate discussion of the gas turbine, but this book disposes of it in less than two pages.

It cannot be expected, of course, that the author of a book of this general character will provide an exhaustive treatment of every item touched upon. But it is up to the writer of books to make it clear to the reader how far short of exhaustive the treatment presented really is. The bomb calorimeter, for instance, is described and there is a page on the procedure to be followed during a calorimetric test. This purports to include instruction in making the necessary temperature correction, but the reader would be hard put to it to find from this the correction to apply in a given test. In practice the temperature-time curve during the chief period is far from being of a balanced S form, and it is highly unpractical to suggest that the temperature of the surroundings should be arranged to fall halfway between the temperature at ignition and the maximum. There is a simple procedure for estimating with sufficient accuracy the Regnault-Pfaundler correction, whatever may be the temperature of the bomb relative to its surroundings. Lacking a description of this, Mr. Wrangham might well have left out the reference to temperature correction altogether.

In his preface he makes much of the use of colour in some of his illustrations and diagrams. But such a practice, when applied to the distinguishing of conditions of state on a thermodynamic chart, has its pitfalls, and one of these Mr. Wrangham has failed to avoid. In Fig. 72, which is an entropy diagram for a liquid-vapour substance, he colours a region and labels it "liquid" and shades it off into the region of superheated vapour. This surely arises from the erroneous belief that any given point between the axes must represent some actual or possible physical state of the substance in question.

The reviewer cannot but set his standard according to the price of the book and the claims of the publishers. Had the book been half the price and had it been claimed for it that it provided only an introduction to the various sections of the subject upon which it touches, then it could well have been said for it that it is excellent for its purpose. Its approach to elementary concepts is often most attractive and the diagrams are delightfully clear and simple. The historical notes are designed to convey to the reader the sense that the subject is a vital and develop-

ing one, and the general format of the book is splendid. It is a book which first and second-year students in particular should be encouraged to browse in.

In his preface Dr. Grundy declares his aim to have been to provide a text-book which will cover the practical side of the subject and the accompanying theory to a stage from which an easy step may be made to more specialised books. This is most laudable and should be commended to other authors who are tempted to build a general and advanced treatment of the subject into a single ponderous volume. When Dr. Grundy claims, however, that his book covers approximately a three years' course in a university or a technical college, he must have in mind such engineering courses as do not entail a special study of heat engines. He is on safer ground when he avers that it satisfies adequately the requirements of both the Ordinary and the Higher National Certificate courses.

Within its limits it is an extremely thorough piece of work and can well be recommended to the young student in evening and day classes alike. Its 715 pages contain a wonderfully large mass of material. The book is in two parts. The first covers the relevant properties of matter, the theory of the steam engine, steam turbines, air compressors, internal combustion engines, and combustion. It includes also a chapter on Engine Governors and Balancing, although it must be seldom nowadays that these items find a place in the syllabus of a heat engines class rather than in a class of applied mechanics. This theoretical part never loses touch with practice, for by illustrations and examples Dr. Grundy keeps the application of the theory before the student.

The authors of both these books find difficulty in introducing the subject of entropy. Attempts at a definition of entropy before the idea of thermodynamic reversibility has been made clear are, to say the least, unprofitable. It would be best to let the student, to begin with, take it for granted, and to require him to construct and to use the entropy diagram under supervision. Familiarity with the diagram prepares the way to a proper understanding of the meaning of entropy, and to an appreciation of a rigorous definition of it such as is not to be found in either of these books.

It is not widely understood how far in the teaching of thermodynamics a teacher might go without the use of entropy at all, and it would be good for young teachers to try themselves out in this respect.

Both authors are in difficulties over the term "adiabatic." Originally it applied by custom only to a reversible process; but its literal meaning renders it applicable to all processes, whether reversible or not, in which no heat flows between the thermodynamic substance and its surroundings. This necessitates the use of the term "reversible adiabatic" or "isentropic," but the significance of each of these is lost on a student until he reaches the stage of understanding "reversibility" and "entropy."

Both authors are, by a peculiar coincidence, rather hazy on the matter of petrol rating. Both believe that the octane number is readily obtainable without the use of a variable compression engine, but do not explain exactly how it is done. They are both perhaps equally unfortunate when discussing combustion in the compression-ignition engine in choosing, for purposes of illustration, records published for a particular engine which cannot be accepted as typical of all oil engines.

The second part of Dr. Grundy's book is descriptive and covers steam generators and boilers, engines, condensers, and internal combustion engines. It is well done and might be prescribed as a course of reading for mechanical engineering students. A useful chapter describing the testing of boilers and engines is included, and appendices covering, respectively, the cathode ray type of engine indicator, the influence of acoustical velocity on the discharge of gas from a nozzle, and the polar planimeter round off the book.

This volume is especially notable, not only for the carefully selected worked examples which it contains, but also for the excellent choice of the numerous unworked examples, to each of which the answer is given. Dr. Grundy gives the reader good value for his money.

The recent spate of books on heat engines, all of which cover much the same ground, makes one inclined to think that rationalisation is called for. Let all the matter that is common to all these books be abstracted and there remains a relatively small residue in each case that can be credited to the author. Let this abstracted matter be stereotyped and let future writers on the subject be forbidden to repeat any of it. Few will find themselves possessed of sufficient advanced knowledge to fill a volume, but only those who do and choose to commit it to print will be numbered with the great.

Drainage and Sanitation. By E. H. BLAKE, C.B.E. Sixth edition. Revised by W. R. JENKINS, B.Sc., Assoc. M. Inst. C.E., London: B. T. Batsford, Ltd. Price 15s.

WHEN a book on subjects such as those dealt with in this volume has, within twenty years, reached its sixth edition, it is obvious, first, that it is not likely to contain passages which are without significance with respect to the methods of to-day; while, in the second place, both the number of the revisions and their frequency must reflect the appreciation of its merits by those for whom it was written.

It would not, therefore, in ordinary circumstances, be necessary to do more than describe the last revisions or merely note that they are adequate; but the war has so disturbed the ordinary contacts of seniors with juniors and of professors with students, and has so altered and deferred opportunities for study, that it seems to be expedient that the character and scope of this book should be, if but briefly, indicated. Its outstanding characteristic is that the various subjects which it presents, each of which would, for the engineer or technician, require a whole volume for its exposition, are brought to bear upon a central idea, as expressed in the sub-title of the book: "A Practical Exposition of the Conditions Vital to Healthy Buildings, their Surroundings and Construction, their Ventilation, Heating, Lighting, Water, and Waste Services." The purpose of the book, as so expressed, is well fulfilled, and it is not to be overlooked—though the publishers have failed to realise it—that the work is one of great value to householders and housing authorities, as well as to the "architects, surveyors, engineers, health officers, sanitary inspectors, and candidates preparing for the examinations of the various professional institutions," for whom, as it is explained on the title-page, it is intended.

The volume contains 558 pages, and is very well illustrated by figures showing main dispositions, schematically; details of appliances; and sectional views of constructions. In detail, dispositions, such as those for preventing dampness and for securing ventilation, are usefully illustrated by small drawings. Recent developments have made necessary the rewriting of the sections relating to warming appliances, water supply, sewage disposal, and refuse destruction, and that containing legal notes. With regard, more especially, to dwellings, the author discusses, first, natural conditions, such as climate, aspect, nature of the site, and subsoil, and other factors which may influence the choice of a house or site. He deals, next, with the planning and construction of the building, and measures for dealing with rain and ground water and for preventing dampness. He proceeds to discuss and expound provisions for ventilation, warming and lighting, sanitation and waste-water disposal, water supply, and drainage. There are chapters on sewerage, sewage disposal, the materials used in sanitary work, sanitary surveys, and reports, refuse disposal, street cleansing, disinfection, and smoke abatement. The work is one of wide scope, in that it relates to many services and professions, but except with regard to water supply, sewerage, sewage disposal, and street cleansing—which subjects are carried beyond the "radius," as it may be called, of the main theme—the volume is devoted to the subject as described in the sub-title, the buildings being such as are occupied, permanently or by day; with special consideration of dwellings. The sciences involved are, as far as necessary, simply explained, and no space is wasted on unnecessary technicalities. Bad dispositions, structural or those of equipment, are shown to be wrong, and the superiority of those which the author recommends made manifest.

The book is one to be studied by all officers of local authorities; but for those directly concerned with housing, an abridged edition, prepared almost entirely by selection from the existing text, including whole chapters, might, it is suggested, be prepared. As time passes new centres of interest attract arts, crafts, and sciences to orbital attendance. The "council house" is one such new focus, the importance of which does not, however, detract in the smallest degree from the value of Mr. Blake's *motif* or from the development of the theme which Mr. Jenkins has so ably sustained in the fifth and sixth editions of this standard work.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

PROGRESS AND INDUSTRIALISTS

SIR,—Your correspondent, Mr. Symington Macdonald, lays his finger on a tender spot when he questions the value of the technologists' report on any invention, and especially so when the invention has been demonstrated, and it is perhaps worth while to trace through the thought processes which may be assumed to apply to all concerned when a manufacturing firm examines an invention with a view to its development, subject to an expert's favourable report.

Taking the inventor first, if he has succeeded in demonstrating his invention, he may be pardoned for believing that on that particular subject he knows at least as much, and probably more than, any expert in general engineering matters, for he may have specialised for many years on a single goal, but the most honest of inventors may be biased in favour of his own ideas, and for that reason alone those considering its development are bound to be careful.

If the prospective purchaser or licensee is a limited company, as so often will be the case, no technical officer of that undertaking cares to shoulder the entire responsibility of advising

his board to lay out perhaps a large capital on a new business without the confirmation of other authority, so he calls in the expert.

The expert is, however, paid to "pick holes." It is not his duty to encourage invention in such a case, but to search diligently for every defect he can see or imagine, but it needs very little damning with faint praise or praising with faint damns to kill any incipient enthusiasm which the invention may have kindled in the breast of the manufacturer, and the higher the status of the advising expert, even when reporting on what may be entirely novel ground to him, the more retarding must be his report if it raises any objections at all.

The case of Giffard's injection is perhaps exceptional from the apparently paradoxical nature of its action, but so far as I can recall its history, its feasibility was stoutly denied by the technologists of those times, long after the inventor had proved its worth beyond all argument, and for a long time he had the utmost difficulty in obtaining its commercial recognition, and notwithstanding the small capital needed in this case.

We thus find, as matters at present stand, that with the best intentions in the world the hands of all concerned, excepting the inventor himself, are directed rather toward retarding progress than toward advancing it, and until some entirely unbiased technical board is appointed by the State to examine and report on invention, with a view to helping rather than hindering progress, when the invention is deemed worthy, it is difficult to see how this can be avoided. ONE OF THE P.B.I.

December 12th.

ENGINEERS AFTER THE WAR

SIR,—If Lord Sempill had had time to search your files, he would have found that engineers have not been so absorbed in technical subjects to the exclusion of economic and social questions as he appears to think. Many of the points he made in his excellent address have appeared, for example, in certain addresses printed in the "Proceedings" of the Institution of Mechanical Engineers and in your leading articles. Engineers have been only too painfully conscious that the benefits their work might confer on humanity have been obstructed by an obsolete financial system, by short-sighted politicians, and by economic "experts" who follow political rather than scientific lines. The engineer hardly makes his voice heard in public policy because the politician and the political economist have the soap boxes and the megaphones. So long as engineering and politics are both full-time jobs, and so long as elections are fought on party lines, there will continue to be few engineers in the House of Commons.

The remedy after which I hanker is to make the House of Lords into a real Senate of all the talents by abolishing the hereditary right to sit, and instituting election by the chartered societies of all the professions from amongst their own members. There should also be a limited number of seats for distinguished public servants, such as judges, sailors, soldiers, and airmen, ambassadors, and civil servants, drawn from the whole Empire. In a very short time such a Senate would establish an influence which the politician would have to respect.

F. L. WATSON,
M. Inst. C.E., M.I. Mech. E.

Leeds, 7, December 11th.

RESIN METHOD OF INDICATING YIELD

SIR,—May I be permitted to make a few observations on your interesting article on "The Resin Method of Indicating Yield," in your issue of December 4th?

The process of using a brittle lacquer coating to investigate strain distribution is a very valuable weapon for the research worker. However, results published by German, American, and British workers show that Mr. Blair's contention that the use of solvents is not permissible to be inaccurate. This process, using dissolved resins is capable of giving much more detailed results than the method originally developed by the late Professor B. P. Haigh. Indeed, it is now possible to investigate strain distribution without producing yield in any part of the structure, and therefore allowing it to be used for its original purpose. In addition, it should be pointed out that the occurrence of yield in a structure is liable to bring about a redistribution of stress and therefore make the results of an investigation on a structure that is not normally stressed to the yield point of the material unreliable.

Finally, I would like to draw your attention to a report by the writer in the "Transactions" of the Institute of Welding for July, 1942, which contains a fairly complete bibliography of the process. R. F. TYLECOTE.

Birmingham, 19, December 12th.

HIGH-SPEED STEEL

SIR,—Mr. Robert S. Yates initiated a very interesting correspondence, but I consider that the subsequent writers, Dr. S. F. Barclay and Sir Alfred Herbert, have not logically answered the points raised. Can we not try, first, to answer Mr. Yates, and later cover the broader aspect of high-speed steel hardening? I present the following:—

(1) It is possible that the further work and treatments imposed on the scrap ends benefit the high-speed steel considerably by breaking down the original grain.

(2) The mild steel welded shank is probably gripped more securely in the tool holder than previously, and the mild steel shank may have a cushioning effect with greater elasticity than the denser-grained high-speed steel.

To prove the foregoing I suggest:—

(1) Comparative micro-structure of original and salvaged tool bits (I am willing to do a little work for Mr. Yates).

(2) A practical test on machines which Sir Alfred Herbert surely has at his disposal.

On the broader aspect, I agree with Mr. Barclay's last paragraph in his letter of September 25th, and his last sentence, November 13th.

Much could be gained by an educational campaign fostered by a national institute or a Ministry. T. W. WHITING.

Birimingham, 16, December 14th.

Sixty Years Ago

WHEN scanning our old volumes week by week in search of something from the past that may entertain or instruct the present, we have not infrequently found that some trifling record was better worth recalling than more weighty and serious matters. So it is on this occasion, for the real plum in our issue of December 22nd, 1882, is a short review of a book entitled "The Dragon-fly or Re-active Passive Locomotive: A Vacuum Theory of Aerial Navigation Based on the Principles of the Fan-Blower," and published anonymously. Of this volume we wrote: "It is a quarto of eighty-five pages, printed in old-fashioned type on thick hand-made paper, with red initial letters to the chapters. It is a prose-poem." The author had, it appears from his own statement, devoted himself to the study of the flight of birds and insects, and had come to the conclusion "that man can never fly, but that he may be able to rise in the air and transport himself from place to place without the aid of a balloon." Our reviewer regarded this as a distinction without a difference, but it is quite clear that to the author flying meant the use of wings and that he would have excluded from that term all our aeroplanes. Curiously enough, his theory of the flight of insects has a remote kinship with the modern theory of aerial flight. His view was that insects, and particularly the dragon-fly, use their wings to establish around them a sphere which is more or less vacuous, and that this sphere, with the insect inside, floats in the circumambient air as a cork does in water. Those who rejoice in finding in the obscure words of poets prophecies of the future may find in this description a foreshadowing of the part played by the reduction of pressure that exists above a properly designed aerofoil in flight. But what does the science matter when the book itself is a prose-poem printed on thick hand-made paper, with red initials to the chapters? *Eheu! fugaces.* Shall we ever see such things again? If any reader has preserved a copy of this volume we implore him to lend it to us for a day for the refreshment of our souls and the revival of the memory of other days.

South African Industrial Progress

A REVIEW of what he termed the "spectacular progress of South African industries" was given by Mr. R. S. Brooke, Past-President of the Chamber of Industries, on October 11th.

There was, he said, a gross output from industry in 1910 of about 17 millions. In 1939 it was about 173 millions, and probably in the present year it would be 250 millions. In that period of thirty-two years there had been an increase of a quarter of a million workers—from 60,000 to over 300,000. The shortage of skilled artisans, particularly in heavy industry, such as engineering and building, had become more acute with the war, and resulted in the adoption of a basic technical training course in the Defence Force which enrolled 7000 trainees a year ago. Referring to the drift of the European population from the country to the towns, Mr. Brooke said that twenty-five years ago half the population lived in the country, but to-day the rural European population had increased by only 5 per cent., while in urban areas it had increased by 110 per cent.

The attraction of non-European labour in factories in the five main industrial centres was creating a shortage of domestic labour, and was resulting in less efficient labour being available for the domestic employer. The further expansion and productivity of industry, so far as labour was concerned, depended on many factors, such as a substantial increase in the supply of trained and skilled artisans, further increase in the employment of European women, and their greater use in those industries where repetition could be adopted, and the training of native and coloured male workers to a higher standard of efficiency. In regard to the future of industry, Mr. Brooke said there was every likelihood of great endeavours being made to establish the world's markets on a freer basis and to restrict and control protective tariffs. As a gold-exporting country, South Africa probably would have to be prepared to work in harmony with any such international plans, in which case the protective wall behind which many industries had grown up might be definitely retarded.

MISUSE OF TYRES.—In view of the urgent necessity for conserving rubber supplies, the Minister of War Transport has made an Order, to be known as "The Motor Vehicles (Restriction of Use) (No. 2) Order, 1942," which will come into force on January 1st, 1943. This Order makes it an offence to use a motor vehicle or trailer on a road when the fabric of a tyre is showing through the tread. If a tyre is handed to an authorised tyre depôt before the fabric shows, it can usually be retreaded and the equivalent of a new tyre produced, using less than 50 per cent. of the crude rubber necessary to manufacture a new tyre. If, however, a tyre is used after the fabric is visible, it is beyond repair—it can never be retreaded and is ruined for further use. Any offence under the Order may be punishable, on summary conviction, by imprisonment for a term not exceeding three months or by a fine not exceeding £100, or both.

GUAYULE PLANTATION AT SALINAS, CALIFORNIA

(For description see opposite page)

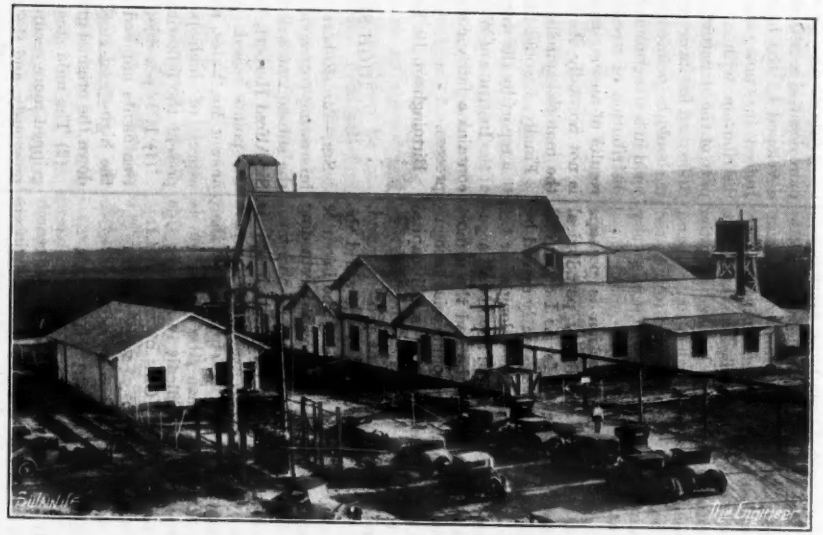

FIG. 1—MACHINE FOR GATHERING SEEDS

FIG. 2—"TOPPING" SEEDLINGS BEFORE TRANSPLANTING

FIG. 3—HARVESTER, PICKING UP, CHOPPING, AND BINDING

FIG. 4—MAIN BUILDINGS OF THE PLANTATION

Rubber from Guayule

WHILE the synthetic rubbers serve many purposes as well as does the natural product—are even better for some, it is said—there are some products for which they are not so well adapted, at least when used alone. In the manufacture of tyres, for example, it has so far been found necessary to use a certain proportion of natural rubber for satisfactory results.

The great need for rubber of any kind, and especially the need for some natural rubber, has caused the U.S. Government to intensify investigations into rubber-bearing plants adapted to culture in that country, and to start actual production of the more promising ones. There are a number of such plants, both native and imported, which are capable of producing greater or lesser amounts of rubber. This article is concerned with guayule. Guayule rubber is the same kind of rubber as that produced by the Hevea tree of the East Indies, and while the two have slightly different properties in some respects, they are readily interchangeable for most purposes. Guayule rubber makes excellent tyres, used either alone or in onjunction with other rubbers.

Guayule is a shrub, with the botanical name *Parthenium argentatum*. It looks a good deal like sagebush, and grows wild in North-Central Mexico and an adjacent area in the "Big Bend" section of Texas. The mature shrub is usually 3ft. or less in height, and has crooked, brittle branches. Its leaves are slender and greyish-green, with slightly irregular edges, and the many inconspicuous yellowish flowers are borne on short slender stems.

In its native habitat, guayule grows generally on outwash fans of limestone soils, where the soil is light in texture and well drained. As indicated by its natural range, it requires a mild climate, though dormant plants have withstood a temperature of 5 deg. Fah. without being killed. It is very drought-resistant and can live where rainfall ranges from 10in. to 15in. per year. Like most other plants, though, the better the growing conditions, the larger and faster it grows.

Unlike the Hevea rubber tree, where the rubber is contained in the sap and is drawn off by tapping the trunk, the guayule shrub deposits pure rubber in the fibres of the plant itself, under the bark. It deposits the rubber when soil moisture begins to run short, so for most effective rubber production the plant requires a relatively short, wet growing season followed by a long, dry period. This is the condition that obtains where the plant gows naturally, and that must be present where it is to be grown. If moisture is available for growth too much of the year, little rubber is produced.

The guayule plant deposits some rubber each year of its life, and may live for twenty years or more. However, under cultivation the peak of production is reached during early maturity, and since the plant is destroyed in recovering the rubber, the most economical cropping period is four or five years. Under optimum growing conditions, the rubber content of the shrub, when dry, ranges from 18 to 22 per cent. of its weight. In case of need, it may be harvested earlier, but with a corresponding reduction in yield. The rubber occurs in both the branches of the plant and the roots, and extraction is accomplished by crushing and pulverising the shrub and floating the rubber particles off on water.

It was not until about 1904 that large-scale production of guayule rubber got under way, with the erection of processing plants in Mexico and Texas. By 1909, 30 million dollars of American capital was invested in the business, and the factories have exported some 4000 tons of rubber annually. The figure for 1940 was 4106 tons. There is no longer a factory in Texas, but four of them operate in Mexico.

One of the early operators in Mexico was the Intercontinental Rubber Company. In 1912 the company decided to try domesticating guayule in the United States, and Dr. W. B. McCallum, chief botanist for the company, collected seeds from several hundred strains of the plant, which he took to southern Arizona. There experimentation was started, looking both to improving the productiveness of the plant and to finding situations suitable for growing it commercially.

Later, it was decided that the Salinas Valley of California offered the best climatic conditions for both continued experimentation and commercial production, and the operation was moved there in 1924–25. A mill capable of producing about 10,000 lb. of rubber per day was built, and since that time about 8000 acres of guayule has been grown in the valley and processed in the mill. The rubber has been sold under the trade name "Ampar," and used for many purposes, including the manufacture of tyres.

Of much greater importance, however, is the fact that over the intervening thirty years Dr. McCallum kept up an elaborate and painstaking experimental programme, which has greatly increased the productiveness of the guayule shrub. The wild shrub, which, of course, is of all ages when harvested, turns out on the average about 10 per cent. of its dry weight in rubber, while the best of the improved strains make around 20 per cent. at five years of age. At the same time experiments were carried on to discover the strains best suited to various situations of growth. The hundreds of strains with which the research programme originally started have been boiled down to about ten, of which four produce the bulk of the actual planting stock. There is no reason to suppose that the limit has been reached in breeding up the plant in productiveness or in adapting it to diverse growing conditions. Thirty years is a very brief time in which to improve a long-lived plant such as guayule.

Because of the generally low world price of rubber, the company had never felt justified in embarking on a large production programme, but it did perfect machinery and methods of culture and processing adapted to production on any scale, should occasion ever warrant expansion. Of still greater importance, when the country began looking for a source of rubber supply to take the place of East Indian imports, was the fact that some 23,000 lb. of seed from the best strains of guayule had been collected and were in storage available for planting. This seed, together with all its equipment and properties in California and patents in this country, the company offered to the Government. By an Act adopted March 5th, 1942, Congress authorised the Secretary of Agriculture to acquire them and to embark on a 75,000-acre production programme.

Because of its experience in operating large-scale nurseries and tree-planting jobs, both on the National Forests and on Mid-Western farms under the Shelterbelt Project, the Secretary of Agriculture turned the operating phases of the guayule programme over to the U.S. Forest Service. Research in connection with it was vested in the Bureau of Plant Industry, which is especially equipped for such investigative work. At once the "Emergency Rubber Project" was organised with Major Evan W. Kelley, Regional Forester at Missoula, Montana, as Director, and Paul H. Roberts, formerly Director of the Shelterbelt Project, as his associate. The Bureau of Plant Industry set up a research staff in connection with the programme, under the direction of Dr. A. C. Hildreth, formerly Superintendent of the Cheyenne Horticultural Field Station, and such bureaux as Agricultural Chemistry and Engineering, Entomology and Plant Quarantine, and Soil Conservation Service furnished technicians in their respective fields. Administrative personnel was drawn from various units of the Forest Service, and within a matter of days ground was being broken for large new nurseries as the first step in the expansion programme.

Three nurseries, containing 530 acres, were created from leased farm land and equipped with overhead irrigation systems. These nurseries contain 1100 miles of seed beds, each seven rows wide, and are capable of producing 350 million or more seedlings suitable for transplanting. They were seeded with the entire 23,000 lb. of seed acquired from the company. A labour camp, comprising forty buildings and designed to accommodate 1000 men, was erected, as was also a seed processing and storage plant, and many minor structures. Using seedlings growing in the company's nursery at the time, 900 acres of guayule plants were set out on land leased in the Salinas Valley. The Government took over from the company some 600 acres of guayule plantations of various ages. Some of the plots are now mature and can be harvested any time they are not needed for seed production.

Guayule reproduces by means of seed, and seed collection is one of the vital elements of the cultural programme. The seeds are very fine, and are borne on slender, upright stalks. The rubber company had developed a mechanical seed picker, which utilises the vacuum principle to suck the seeds up into a container—Fig. 1. It is quite successful, though naturally somewhat wasteful of seed. During the first seed collection campaign, the Project reverted to hand-picking methods in order to get all the seed possible. More than 100,000 lb. was thus secured. The plant bears seed from its first year onward, and under proper growth conditions is a quite prolific seeder.

FIG. 5—DE-WEEDING SEEDLING BEDS

Guayule seed does not germinate readily if planted in its natural state, but a process of treatment before planting was finally evolved, which results in germination of a satisfactory proportion of it. After collection the seed is run through a fanning mill to remove trash and chaff, and is then placed in perforated drums which revolve in water. It is allowed to stay in this bath for twenty to twenty-four hours, when the water and sediment are drawn off and the bath refilled with a ½ to 1½ per cent. solution of calcium hypochlorite or sodium hypochlorite. The seed is soaked in this solution for from two to four hours, when it is again washed to remove the excess chemical, and then put through a centrifuge to remove surplus water. It is ordinarily planted while it is still moist.

If the seed is to be stored it is dried when it comes from the centrifuge and stored in air-tight drums. It may also be stored as it comes from the field, but must in any event be treated as above described before planting, unless it has been in storage for several years, when the treatment may be diminished or even dispensed with. Seed may be stored for several years without losing its viability, thus permitting a supply to be kept on hand against lean seed-production years.

The seed is planted in the nursery bed by an ingenious seeding machine, which sows a complete bed—seven rows—at one time. The beds are 4ft. wide—Fig. 5. Essentially, the machine lays the seeds on top of a finely prepared seed bed, then to keep them in place lays a thin layer of white sand on top of them. Immediately the bed is sown, it is wet down with the sprinkling system and is sprinkled frequently thereafter until the plants are up and have struck root. Thereafter they are watered less frequently, though they are always given sufficient water to keep them growing at the rate desired. The beds must be kept free of weeds, and on new land this may prove to be a problem. While specially designed cultivating machinery cleans the space between the rows, weeds in the rows must be removed by hand—Fig. 5. During the early growing season the Project had to recruit some 3000 workers—largely women and girls—to clean the beds of the weed crop that came up.

Once the young plants become established, they grow rapidly, and in from four to five months are ready for transplanting. They are reduced to uniform height by a mowing machine which clips the tops—Fig. 2—and are then loosened in the bed by a blade which is drawn along under the plants and shakes them loose. They are then pulled by hand, root-pruned to remove objectionably long roots, sorted, and the usable plants packed in boxes with wet moss or shingle-tow about the roots for shipment to the field. Sometimes if the planting season is far advanced, the roots are soaked for an hour in a medium-strength solution of potassium permanganate to stimulate root development. The chemical also serves somewhat as a fungicide in root rot control.

The seedlings are transplanted in the field by means of tractor-drawn planting machines, which plant four rows at a time. For each row a sub-surface tool opens a slot in the earth deep enough to accommodate the roots of the plants. Men on the machine—one for each row—feed seedlings into mechanical fingers, which, in turn, insert them in the opened slot. A pair of packing wheels which follow close the slot and firm the soil about the roots. The rows are planted 28in. apart, and the plants spaced from 20in. to 24in. in the row, depending upon the quality of the planting site and whether or not the land is irrigated. The machines plant about 10,000 seedlings per hour on the average, or 10 acres per ten-hour day. Like any other row crop, guayule must be well cultivated and kept clean. While it competes successfully—however slowly—with the other vegetation of its native habitat, it will not compete with weeds and grass on agricultural land, and make sufficiently rapid growth to justify its occupancy of such land.

The shrub is harvested by a machine which digs out the plants, including the principal roots, and piles them up in a windrow. The windrow is then picked up by another machine—Fig. 3—which chops the shrub up and blows the chopped material into a truck trailer, ready for transport to the factory. If it is desired to store the shrub for a time before processing, it may be baled like hay and stacked in any convenient place.

FIG. 6—VIEW OF PLANTATION

Guayule has not many important natural enemies. A few insects, notably grasshoppers and June beetles, may do moderate damage to it, and some mammals, including sheep and goats, will eat the plant if pressed for food. It also is not subject to many diseases. The principal ones are certain root rots, which ordinarily occur, however, only when the plant finds itself on heavy or poorly drained soil, and a crown rot which may appear if water stands around the plant. These diseases may be aggravated by any condition which prevents normal drying of the topsoil, such as lush growth of the plant. Plants just emerging from the seed occasionally fall victim to the "damping-off" fungus, common to a great variety of plants, but it generally is not serious in the nurseries. In short, like most desert plants, guayule is pretty tenacious of life once it gets started.

When the chipped shrub is brought to the factory, it is put through a series of rolls and mangles, which reduce it to a very finely shredded condition. This material, with a carefully controlled addition of water, is then fed into the upper end of a "pebble mill." The pebble mill is a long tube, lined with very hard silicon bricks and partly filled with a special kind of smooth pebbles. The tube rotates and the material in it is thus ground between the pebbles and the lining, separating the rubber particles from the plant fibres. Emerging from the lower end of the tube, the mass goes into a settling tank, where the water-logged woody material sinks and the rubber floats to the surface, the particles agglomerated in the form of "worms." These worms are then put through certain cleaning processes, where the last of the plant fibres are removed. The rubber is spread out on trays and dried for three or four hours in vacuum driers, and then pressed into slabs about 5in. thick, weighing 100 lb. Two of these slabs are packed per box for shipping purposes.

Guayule rubber extracted by this process contains about 16 per cent. of resins. These resins are not mixed with the rubber in the plant, but become unavoidably mixed with it in the milling process. For some products the resin content is not objectionable; for others, it must be removed or diminished. Tree rubber contains about 4 per cent. of resins. Since the war began, resins such as are contained in guayule rubber have become valuable in the manufacture of plastics, so that the de-resinating process may now pay its own cost or even produce a profit.

The Project nurseries in the Salinas Valley contain about 350 million seedlings, sufficient to plant some 32,000 acres of land. These are being planted during this winter. In addition, if the statutory limit of 75,000 acres of guayule plantations should be lifted, thus justifying the establishment of additional nurseries, sufficient nursery acreage may be seeded with seed collected during the summer to provide stock for an additional 31,000 acres, to be planted in the spring of 1943. Thus up to 63,000 acres of guayule could be planted during the 1943 crop year. It is planned to use both irrigated and dry land in the production programme. Since on the average irrigated land may be expected to produce more rubber in a given length of time than dry land, for the time being at least the greater part of the acreage will be confined to it.

As indicated previously, guayule requires certain conditions of soil and climate for successful culture, and a reconnaissance survey of California was made to locate the areas adapted to it. More intensive surveys within these areas are made as required in connection with the leasing programme. In general, the areas are found in the coastal valleys from Monterey County south, along the west side of the Sacramento and San Joaquin valleys, the Imperial Valley, and scattered small areas in Riverside and Imperial counties. Further expansion of the Project is possible in Arizona, New Mexico, and Texas, where adaptable lands are known to exist.

As time goes on, the shrub may be found to be adapted to other areas now considered infeasible for one reason or another, or the plant itself may, by selection and breeding, be adjusted to other conditions. Already a large number of indicator and test plots have been set out over the suspected possible range of the plant, and experimentation is under way looking toward producing strains resistant to some of the principal hazards which now prevent otherwise excellent land from being considered for guayule culture.

Production of guayule rubber from plantations has so far been on so small a scale, and costs have been so influenced by the developmental character of the operation, that there are no existing figures that would be of much value in forecasting the cost of such rubber under full-scale production. The present Governmental production programme is a war effort, aimed entirely at helping to relieve the critical rubber situation, but it is not beyond the bounds of possibility that it may also result in developing both a permanent at-home source of rubber and a profitable crop for agriculture. As a crop, it is "easy" on land, occasioning less drain on soil resources than many other crops, and since genetic research in connection with the plant itself is really only in its infancy, there is every probability that both its productiveness and its tolerance to growth conditions will be improved.

The British Merchant Shipbuilding Progamme in North America, 1940-42*

By R. C. THOMPSON and HARRY HUNTER

(Continued from page 483, December 11th)

MACHINERY : GENERAL

BEFORE the Mission left England it was recognised that the usual type of British trampship machinery, namely, reciprocating steam engines with coal-fired Scotch boilers, was not available to any extent in North America, and while this was the preferred type, the Mission was left a free hand in the matter of machinery type. Such machinery was looked on in the United States as archaic, particularly the use of coal as fuel for ocean-going ships ; however, at the end of 1940 coal was certainly a fuel still readily available to Britain, and it seemed advisable from the manning point of view to adhere to a familiar type of machinery with the avoidance of anything of the nature of a "technical adventure." It is of interest to note that the U.S. Maritime Commission adopted the identical main engine design and much other equipment for the "Liberty" ship programme ; in that case the primary consideration was that of getting into rapid production on a large scale.

A preliminary survey in the United States confirmed that such machinery was not available as a regular product, that a large production capacity was available with suitable plant, but that in the case of many items no suitable substitute was available, and we would have to supply the designs to firms deemed competent to execute them.

In the case of other items, U.S. equipment was available of different design to the British, but otherwise suitable, and in such cases the U.S. equipment was adopted.

In Canada the situation was rather different, as the Admiralty already had corvettes under construction with similar machinery to that in the proposed freighters, and firms were already in production on much of the required equipment to British designs. Apart from this, Canadian shipbuilders and associates were more familiar with British practice and requirements.

The above circumstances account for the U.S.-built "Ocean" class having a mixture of United States and British design equipment, all made in the United States, while the Canadian-built "Fort" class have mostly British-design equipment of British or Canadian manufacture.

A further factor governing the arrangements for manufacture of the larger mechanical equipment was the necessity for getting into production quickly, as it was early evident that the shipbuilders might well have ships ready for equipment unexpectedly early.

MACHINERY : SPECIFICATION AND TECHNICAL NOTES

The main engine contract in the United States for both yards was with the General Machinery Corporation, of Hamilton, Ohio—a concern which includes Hooven Owen and Rentschler, the well-known former marine engine builders. This company had built large numbers of marine engines in 1918–20, but since that date had built virtually no marine engines. The contract with this concern for sixty main engines was entered into in January, 1941, and the first engine was delivered on July 7th, 1941, and the sixtieth on January 1st, 1942, and during the two months of December, 1941, and January, 1942, twenty-seven engines were delivered.

The design of main engine was British (North-Eastern Marine) and engines to the same drawings were fitted in the Canadian ships and also in the Maritime Commission "Liberty" class. This arrangement permitted the interchange of engines in the various programmes, and, of the above-mentioned sixty engines, thirty were fitted in Maritime Commission ships and subsequently replaced by engines built against Maritime Commission orders. This interchange, and others of a similar nature, was effected under an agreement with the Maritime Commission, which finally resulted in both U.S.A. and British programmes drawing as required from common production lines.

In Canada the main engines for original British contracts were built, by the Dominion Engineering Works, Ltd., Montreal, and Canadian-Vickers, Ltd., Montreal. These firms had built during the preceding twelve months a number of corvette engines, and were able to get into production rapidly and meet all shipbuilders' requirements. Eventually when the United States and Canadian Government programmes were developed early in 1942, there were four engine builders in Canada and ten in the United States, all building the same design of engine to a total number approaching 2000.

As with other British designs, the British drawings were not immediately suitable for issuing to the United States and Canadian shops. British marine engine builders and other manufacturers in general leave many details off the drawings to shop practice—an arrangement which works out very well when the staff has grown up on the job, and where the whole unit is usually cast, machined, assembled, erected, installed, and delivered under the one roof. For U.S. conditions, however, it was necessary to amplify and redimension the British plans in respect of tolerances, fits, and clearances, degree of finish, fillets, &c., and also certain other modifications to meet U.S. standard flanges and standard fittings. Apart from these items and the use of U.S. threads, spanner sizes, &c., the main engine design followed the British parent design. The Canadian engines in the above items generally follow British practice. Also the British practice is to include many items on the one tracing, and it was necessary to break these down into single-item plans.

The above process of "interpretation of British plans" was a very substantial item, and in the case of the main engine the eighty British working plans were expanded into about 400. A similar proportion prevailed in other items, including hull plans.

The main boilers were of the three-furnace Scotch type, and for the U.S. ships were built by one firm in the East and two on the West Coast.

The East firm was the American Locomotive Company, of Schenectady, N.Y., whose contract for ninety boilers complete with fittings, mountings, and superheaters, was placed in January, 1941. This firm had built several Scotch boilers some years previously, but the present contract was their first serious experience with such boilers. They had, however, built very many locomotives of the largest size up to 500 tons weight, and it was thought that such experience justified their being entrusted with the large marine boiler contract—a procedure subsequently fully justified. The first boiler was completed on April 28th, 1941, and the last in September, 1941, the attained and maintained output being twenty-five boilers per month.

The West Coast boilers were ordered from two firms—the Western Pipe and Steel Company, Los Angeles, and Puget Sound Machinery Depôt, Seattle (formerly Garrett and Shaeffer). The first-named company had no previous experience with Scotch boilers, but was a well-equipped plant accustomed to handle high-pressure equipment for the oil industry. The second company had built a large number of Scotch boilers in 1918–21 and occasional boilers thereafter, and had the staff and equipment required for the job.

In the event, the West Coast hulls made rapid progress—running several months ahead of contract schedule, and the West Coast boilers could not be accelerated quite sufficiently ; the East Coast boilers, however, were ahead of schedule, and the first West Coast ship was therefore fitted with East Coast boilers, the boilers being transported 3000 miles by rail from Schenectady to San Francisco. After the first ship, the West Coast boilermakers were able to meet all requirements of West Coast ships.

As with the hulls, the use of welding in the boiler construction was fully considered, along with other modifications to the British designs to meet the manufacturing facilities. In welding, perhaps the most important adoption was in the joint of the combustion chamber wrapper plates to the tube and back plate, where a butt weld with main run from outside and sealing run from inside was adopted. This procedure had the advantage of avoiding the rather specialised workmanship involved in the usual riveted lap joint. The wrapper plate butt was also welded, thereby avoiding the usual awkward three-ply joint. In some plants the wrapper plate was made in two portions with two welded butts for the purpose of facilitating manufacture.

Shells were riveted to British design in all cases with sealing welds at strap ends, the large size of shell presenting difficulties in welding and stress relieving. Combustion chamber stays were nutted inside, except in the case of lower rows in way of curvature of wrapper plate. In this locality, to avoid the use of bevelled washers, the stay end was welded to the wrapper plate, giving a pan-head finish. In some Canadian boilers unscrewed blower tubes were fitted, the tubes being welded at ends to plates. In some boilers, where the end plates or heads were in two portions, the seam was welded in lieu of lap riveting. This construction avoided the awkward three-ply joint in the usual construction.

An interesting situation developed in connection with the U.S. method of flanging end plates, the flanging being carried out by a "spinning" process, as described below :—

The end plate, about 17ft. in diameter, is heated to the flanging temperature and placed on a horizontal face plate, about 12ft. diameter, and is held thereto by a hydraulically operated upper face plate of rather less diameter than the lower face plate. Towards the rim of the end plate are two rollers—the inner and outer. The inner roller has a vertical axis and is adjustable radially and vertically, and has its edge of the same radius as that required in the flanged plate. The outer roller has its axis capable of angular adjustment, and is also adjustable radially. The end plate is rotated at about 45 to 50 r.p.m., and is first centred by means of the outer roller, and is thereafter finally held central by the upper face plate. The two rollers are now manipulated so as to give the required flanging, an operation carried out in one heat and taking from ten to twelve minutes.

Such machines were installed at the steel works and the end plates were delivered to the boiler shops in the flanged conditions. End plates flanged in this manner have flanges very true in the cylindrical sense and avoided the rather specialised workmanship involved by the usual British method of "local" flanging. Such an operation, however, requires a complete disc of uniform thickness, whereas the Scotch boiler design demands two thicknesses of end plate, in this case $1\frac{7}{16}$in. steam space and $\frac{31}{32}$in. in lower portion.

The following methods were used to meet the above requirements :—

(1) Complete $1\frac{7}{16}$in. end plate spun and subsequently two segments cut off to form two steam space portions, the material between segments being reject. Two complete $\frac{31}{32}$in. end plates spun and segments cut off to form lower portion of end plate, the smaller segments being reject and the top and bottom portions of respective plates riveted or welded together to form complete end plates. This method involves considerable rejection of material.

(2) Two complete $1\frac{1}{32}$in. end plates spun and $1\frac{1}{32}$in. doubling plate riveted and seal welded to steam space portion of end plate.

(3) One complete $1\frac{7}{16}$in. end plate spun and cut into two segments, the smaller segment A becoming the front upper portion and the larger segment B becoming the back upper plate. One complete $\frac{31}{32}$in. end plate spun and cut into two segments, the smaller segment C becoming the back lower portion. Segments A C and B D welded together, the joint being horizontal, and at the front between the top row of tubes and lower row of steam space stays ; at the back the joint is between eighth and ninth row of stays.

In general, in the United States the West Coast boilermakers worked to scheme (2) above,

* Eleventh Andrew Laing Lecture, North-East Coast Institution of Engineers and Shipbuilders. Condensed

and the East Coast makers to scheme (1) and latterly scheme (3) above.

In Canada the main boilers were built by four firms, namely, Dominion Bridge Company, Montreal and Vancouver; John Inglis and Co., Toronto; Vancouver Iron Works, Vancouver. These firms all had, to a greater or less extent, previous experience with the manufacture of Scotch boilers, and the boiler end plates were, as in the U.S. boilers, spun and ends made by scheme (1) above, and combustion chambers were mostly welded as described above. Messrs. Inglis, however, fitted riveted combustion chambers and end plates in accordance with scheme (2).

A difference between the U.S. and Canadian boilers is that the mountings in the former are to U.S. standard flange tables, whereas the latter are to British standards.

All boilers, U.S. and Canadian, are fitted with smoke tube superheaters, giving the moderate steam temperature of 520 deg. to 550 deg. Fah. This temperature was deemed preferable as it permitted the use of a superheater able to withstand considerable abuse. The manning of ships with engineers having experience with superheaters received consideration, and all ships had chief engineers, or at least the second, with superheat experience.

In respect of deck and auxiliary machinery, as previously mentioned, the U.S. and Canadian ships differed. In each class, however, as with the main engines, a single design was adopted, and as the programme expanded other firms worked to the same design with the original maker as leading firm.

INSTALLATION

The fact of the hulls being welded had a number of reactions on the machinery, the following being the principal items of interest.

In the United States the general practice is to install propelling machinery, including main engines, boilers, and shafting before launch. This practice enables the ships to be closed up before launch, a particularly desirable feature in the case of a welded ship. In general, the main engine and shafting will be temporarily positioned before launch and the chocks finally fitted when the hull is water-borne.

Owing to the effect of contraction of the top side welds, there is a pronounced tendency for the vessel as a whole to sag, and, in addition, contraction stresses can set up local deflections of the aft end; that is, the stern frame is liable to distortion apart from the hull structure, quite an important matter when boring out for the stern tube. The amount of hogging is of the order of 1in. to 2in., and is counteracted to a large extent by sagging the keel blocks by 1in. at each end. Alternatively, the tendency can be counteracted by leaving the upper shell and decks free in way of forward and aft hatches, and leaving welding here to the last. Either way, however, the stern tube is best not finally sighted until the top side welding from 'midships to right aft is completed.

A second form of deflection was also experienced, particularly in the Richmond yard, where it was found that the hull had a substantial variation of distortion during a twenty-four-hour period—due presumably to the heating effect of the sun. This daily variation was probably more pronounced because the ends of the ship were more or less "afloat," as it were, due to the previously mentioned top-side contraction. Measurements disclosed that the stern tube line was in a mean position as between 12 midnight and 2 a.m., and this time was adopted for final sighting through and marking off.

Another item where the welded hull called for special attention was in the fitting of chocks under the main engine. In a riveted ship the top plate in way of holding-down bolts remains very fair and level, permitting the chocks to be conveniently fitted from outboard of the bed-plate. In a welded ship, however, the top plate, due to contraction of welds at the top of floors and longitudinals, is not so regular, and may present difficulty in the proper fitting of chocks. In general, and in the case of all British ships, the top plate could be levelled off in way of chocks by grinding locally so as to give the desirable parallelism or slight inward taper of the packing space. In some yards, however, where the distortion was more severe, the practice was adopted of welding pads, about ½in. thick, in way of each holding-down bolt and dressing off the top of pads.

As previously mentioned, in the U.S. British yards, as in all new U.S. yards, the machinery is as a rule installed before launch. It should be noted, however, that the yards were laid out with this in view and the berth cranes were of a capacity to deal with machinery weights. Each yard also had a large fitting-out jetty, with about 2500ft. of water frontage, well covered by four cranes, and with large machine and pipe shops, &c., conveniently located.

Installation at the shipyard before launch is also facilitated in the United States by the capacity of rail transport from the engine and boiler works to the shipyards, the loading gauge being considerably greater than in this country.

ORGANISATION

Headquarters of the Mission was at the British Purchasing Commission, New York. This was distant up to 3000 miles from the various yards, but owing to their excellent air travel facilities in North America, such distances were of no great significance. As already mentioned, the design and purchasing sides of both U.S. yards were centralised in New York, and with Montreal only two hours' distant by air, the former city proved entirely suitable. A typical trip around the various shipyards, engine works, and boiler works involved the following route:—New York; Hamilton, Ohio; Los Angeles; San Francisco; Seattle; Vancouver; Montreal; Quebec; Portland, Me.; New York—a total distance of about 11,000 miles, which, however, by air travel could conveniently be covered in two or three weeks.

For detail technical supervision in the United States, both in respect of owners' interests and classification, arrangements were made by the Admiralty with Lloyd's Register for a number of surveyors to be employed full time on the British programme, the details being worked out between the Mission and Mr. Bennett, principal surveyor in North America. At each shipyard were stationed five Lloyd's surveyors, the senior surveyor at each yard—Mr. F. C. Cocks at Richmond, Cal., and Mr. J. S. Ormiston at Portland, Me.—acting as local representatives of the Mission with substantial discretionary authority, as it soon became evident that local and quick decisions were essential to rapid progress. The senior surveyors were at the yards well before ship construction actually started, as their duties included "owners' interests" in respect of the shipyards. Full-time surveyors were also appointed to the main engine builders, and to two of the boilermakers (East and West Coast respectively), and special arrangements made for the attendance of surveyors at various other works. These arrangements all took into account the special needs of the situation rather than merely classification requirements.

The primary responsibility for progress was left with the shipyards, each having an expediting department for the purpose. Ultimately, when the Maritime Commission programme developed, that authority evolved a progress set-up in which we participated, and since much of the equipment was identical, both programmes were supplied from a common production line, the allocation being solely determined by the actual progress of ships.

As vessels approached completion three additional appointments were made to each yard by the Ministry of War Transport, namely, marine superintendent, engineer superintendent, and surveyor for statutory requirements. The duties of the superintendents were the general preparation of ships for sea and matters relating to personnel, but in practice the closest co-operation developed between the superintendents and surveyors.

Acceptance of vessels from builders was by the senior Lloyd's surveyor acting as representative of the British Purchasing Commission, and ships were immediately turned over to the Ministry of War Transport. Acceptance in general took place at shipyard after satisfactory sea trial, which latter included six hours' running at full power and usual turning, steering, and manœuvring trials and tests of all equipment. Captains and chief engineers in general arrived at shipyards shortly before launch, other officers shortly before trial, and crews immediately before loading.

ORGANISATION: CANADA

Expediting was originally carried out by the shipyards, but latterly, for all yards, by Wartime Merchant Shipping, with allocations to suit hull progress. Classification was divided between British Corporation Register of Shipping and Aircraft and Lloyd's Register. The classification surveyors also acted in owners' interests jointly with local representatives of Wartime Merchant Shipping. Ministry of War Transport, marine and engineer superintendents were appointed for East and West Coast yards with similar duties to the superintendents in the United States, and similar arrangements were made for personnel.

CONCLUSION

The authors, on behalf of the Mission, would like to conclude by expressing their appreciation of the splendid co-operation afforded by the Admiralty Department of Merchant Shipbuilding, who always were able to take quick action in dealing with the many points which arose, and they would like to acknowledge the high value of services by the classification surveyors and Ministry of War Transport superintendents and surveyors engaged on the programme. Also, progress was greatly helped by the rapid and efficient attention they always received from the British "parent" firms on this side.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

GALVANISED STEEL WIRE ROPES

No. 365—1942. This revision of the Specification for Round Strand Galvanised Steel Wire Ropes for Shipping Purposes differs chiefly from the 1929 edition by the inclusion of a table illustrating the rope construction and the deletion of 90–100 and 90–105 tons per square inch hawser steel ropes and ropes of 8½in. and 9in. circumferences. The amount of pure zinc in the virgin spelter for the galvanising has been raised to 98·5 per cent. The specification is intended to provide for standing and running rigging ropes, hawsers, mooring and towing ropes, and cargo gear ropes.

UNIVERSAL DECIMAL CLASSIFICATION

WE are asked to direct the attention of those of our readers concerned with the abstracting of scientific and technical literature, the compilation of bibliographies, or the classification of scientific documents of all kinds to the fact that the following parts of the English edition of the Universal Decimal Classification, all stocks of which were destroyed by enemy action, are being reprinted by the British Standards Institution. The opportunity has also been taken to make several minor amendments, *e.g.*, correction of printer's errors and errors of translation.

Vol.1, Part 1: General Introduction, Auxiliary Tables, and Class 0, Generalities.
Vol. 2, Part 1: Classes 51, Mathematics; Class 52, Astronomy; Class 53, Physics.
Vol. 2, Part 2: Class 54, Chemistry.
Vol. 2, Part 3: Class 55, Geology and Geophysics; Class 56, Palæontology; Class 57, Biology; Class 58, Botany; Class 59, Zoology.

Vol. 1, Part 1, will be published at 7s. 6d. net, and Vol. 2, Parts 1, 2, and 3, at 10s. net per part. Class 621.3, Electrical Engineering, is in preparation and will be available early in the New Year. Owing to the restrictions imposed by the Paper Controller, the edition will be strictly limited, and the B.S.I. is desirous of ascertaining the probable extent of the demand for the various parts. It would therefore assist the Institution if prospective purchasers would make their requirements known as soon as possible. All orders will be dealt with in rotation, and should be addressed to the Publications Department, British Standards Institution, 28, Victoria Street, London, S.W.1.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer

Alloy Steel Scrap Prices

The urgent necessity for collecting and segregating alloy steel scrap which may arise in workshops has been frequently brought to the attention of the engineering industry. The Minister of Supply has made the Control of Iron and Steel (No. 27) (Scrap), Order, 1942. The Order, which came into force on December 10th, 1942, fixes maximum prices for the following classes of alloy steel scrap not previously separated covered :—

	Per ton. £ s. d.
Manganese-molybdenum heavy steel scrap, free from other alloys	4 16 3
Short heavy shovellable manganese-molybdenum steel turnings, free from other alloys	3 1 3
Carbon-chrome heavy steel scrap, free from other alloys—	
(*a*) For use in high-frequency, electric, and crucible furnaces, in small pieces to the specification of the buyer ...	7 1 0
(*b*) For all other uses	4 16 3
Short heavy shovellable carbon-chrome steel turnings, free from other alloys	3 1 3
Chrome-molybdenum heavy steel scrap, containing not more than 0·5 per cent. nickel, free from other alloys—	
(*a*) For use in high-frequency electric, and crucible furnaces in small pieces to the specification of the buyer ...	8 11 0
(*b*) For all other uses	5 0 0
Short heavy shovellable chrome-molybdenum steel turnings containing not more than 0·5 per cent. nickel, free from other alloys	3 5 0

The Pig Iron Market

There is an active demand for most grades of pig iron and although in some departments there is a tendency for delivery dates to lengthen, this has not reached the stage which gives cause for concern on the part of the authorities. The shortage of hematite has existed for so long that consumers have become accustomed to using substitutes and have proved themselves remarkably adaptable in this respect. The scheme for concentrating the foundry industry does not seem to be making rapid progress, and it is understood that as it now stands the scheme is much less drastic than when it was first proposed. The supplies of high-phosphoric pig iron are ample to meet all requirements and are in excess of the demand, although the latter has improved slowly as more of the light castings foundries have been brought into the war effort. The heavy engineering and machine tool foundries are employed to capacity, and are meeting the requirements of the armaments firms with efficiency. This branch of the industry is a large consumer of low-phosphoric pig iron and refined pig iron. The demand for these qualities has been particularly heavy of late, and the Control is carefully supervising applications for licences. Low-phosphoric pig iron is in almost the same category as hematite, so far as the release of parcels is concerned, and this grade is only allocated when it is required for essential war work. The engineering foundries have lately been obliged to take up a certain amount of high-phosphoric pig iron, although the nature of their work does not permit the extensive use of this description. Jobbing foundries are irregularly employed, but, on the whole, are taking up a fair quantity of pig iron, usually of the high-phosphoric descriptions. There is a large consumption of basic pig iron and in some districts the blast-furnace capacity has been practically concentrated on the production of this kind of pig iron. Great as is the consumption by the steel works, the fears that were entertained regarding the adequacy of future supplies of this iron seem to have disappeared.

The Midlands and South Wales

The Midlands steel works are fully employed in meeting the requirements of the war industries. They have been under the pressure of heavy commitments for months, and are now working at top speed to increase production to clear as many of the orders on their books as possible by the end of the year. The raw materials position is generally satisfactory, and seems likely to remain so for an indefinite period. In the case of the re-rolling industry, with the restrictions on imports, the works have to rely more upon home-produced material, but the production of semis is on a heavy scale, and although inroads have had to be made on stocks of imported semis, the position is sound. The supply of scrap is generally adequate, but there seems to be a scarcity of one or two descriptions, and the demand for heavy steel scrap is somewhat in excess of the supply. There is an insistent demand for all descriptions of steel, and it is understood that steps are being taken to increase the output of special grades which are in strong request. The volume of business in steel bars appears to have increased somewhat over the past week or two and pressure for large and small diameters is heavy. The production of small steel bars and strip by the re-rolling works is sufficient to meet consumers' requirements. There has been a brisk call for reinforced concrete bars. Lately also the consumers' requirements of bar iron have considerably expanded, although the pressure upon manufacturers is not so severe as in the case of steel bars. The iron and steel plants in South Wales are fully occupied, and during December the pressure from consumers to obtain delivery has increased. The volume of business in ship, tank, and boiler plates is an outstanding feature of the market, and large tonnages are passing into consumption. The call for billets and sheet and tinplate bars is active, and Welsh works are supplying semis to other districts. The volume of business passing in structural materials, which improved so much a month or two ago, is showing signs of diminishing. The demand is not more than fair for heavy joists, but there is an active call for light joists and sections. The tinplate market remains dull, but this is principally because of the restrictive effect of Government regulations. The home demand for tinplates is moderate, whilst there is practically no export business passing. Comparatively little interest also is shown in substitutes for tinplates. The sheet mills in South Wales are well employed and have good order books, and there is a strong demand for black and painted sheets.

The North-East Coast and Yorkshire

The increased activity at the iron and steel works in this district which developed at the beginning of the present quarter has been maintained, and the works are operating to capacity. The plants are now working almost entirely on Government contracts and civilian orders are practically non-existent. The demand covers all departments of the steel industry. The production of semis has now reached a very high level, and consumers are receiving a larger proportion of British-produced material than at any time during the war. So great is the demand, however, that the home production has to be supplemented by withdrawals from stocks of imported materials. Imports from the United States have been considerably curtailed, but arrivals are still coming to hand, and although inroads have been made into the stocks, these remain of a substantial character. The demand for plates, which has been one of the features of the position for many months, shows no signs of relaxing. The largest consumers appear to be the shipyards, although the requirements of the tank makers and locomotive builders are on a heavy scale. The heavy electrical engineers are also big consumers, and the combined pressure from these industries is taxing the resources of the plate mills. It is suggested that any further expansion in ship construction will necessitate a further expansion in the production of plates. The requirements of the armaments and aircraft industries are taking up the full output of special and alloy steel and fresh attempts are being made to increase the production. The call for open-hearth steel ingots has increased this month and the producers are hard pressed to meet the demand. The recent heavy call for steel bars has expanded, and large tonnages are passing to the engineering works and other firms employed in the war effort. The re-rolling industry is also meeting with a strong request for small steel bars and reinforced concrete rods. Fortunately, however, this branch of the trade is receiving good supplies of billets, and is able to meet the demand. In the Yorkshire steel-producing districts fresh pressure has been brought to bear upon manufacturers to increase the output of basic steel, although production has reached a high level. There has recently been a considerable increase in the demand for sections, which is reflected in the better conditions ruling in the constructional engineering industry. The manufacturers of special steels are working under great pressure, and fresh efforts are being made to expand the output.

Scotland and the North

The Scottish iron and steel industry is working at capacity and practically the whole production is devoted to meeting requirements arising from the war. Efforts are continually being made to increase outputs, and production is at a high level, although, of course, for security reasons, no figures of production can be given. The plate position is attracting some attention, since, in spite of the big outputs that have been made in this section of the industry for a long time past, it barely meets the requirements of the consuming industries. Talk of a fresh drive to increase merchant shipbuilding has been met by the argument that this will be contingent upon larger supplies of ship plates. Already all available plant is in operation, and it is difficult to see how outputs can be increased. Already the plate mills have enough orders in hand to keep them busy for the next six months. In addition to the shipyards, tank makers are also taking up good tonnages of plates, whilst a stream of new orders is coming to hand from locomotive builders and the heavy engineering industry. Engineers also are continually pressing for supplies of alloy and special steel. There has been a considerable increase in the uses for which this steel is required, and production, in spite of the big increase which has been made since the beginning of the war, is barely sufficient to meet requirements. The recent improvement in the volume of business in structural steel has been maintained. A fair demand persists for heavy joists, but the call is more noticeable in the case of the lighter joists and sections. Producers of structural steel are now fairly well situated, and have a substantial volume of orders in hand. The drive to obtain more coal has resulted in an increase in the demand for steel for colliery equipment. The steel works have met the demand satisfactorily, but some works have orders in hand which will have to be carried over into the New Year. Tightness appears to have developed in the Lancashire market in the supply of forging blooms. Forge masters have drawn rather heavily upon their reserves, and may have to use increased quantities of imported American semis. There has been no relaxation in the demand for plates, which has been increased during recent weeks by more active conditions at the locomotive building works. The call for special steel in the Lancashire market seems to be strengthening, and the demand appears to have outrun supplies. Where possible, efforts are being made to increase the production of this steel. The production of steel bars is on an increasing scale and is passing into immediate consumption. The engineering industry has taken up big tonnages of larger diameter bars, whilst re-rollers report an insistent demand for the smaller sizes. The steel works on the North-West Coast are fully employed and have enough work in hand to keep them busy for some months.

Copper, Tin, Lead, and Spelter

There has been no decrease in the tonnage of copper passing into consumption, and judging by appearances the increase in armaments and munitions production in the last quarter of the year has probably called for even greater quantities of the metal than were previously used. So far as can be seen, imports have been arriving with regularity and there is no reason to suppose that the war industries have not been obtaining their full allocations. So far as can be seen, not only have firms engaged upon war work received the supplies they require, but they have also received them by the dates they were needed. Of course, it would be absurd to believe that no ships containing copper had been sunk by enemy action, but it would certainly appear that the number which met an untimely fate on the sea was not sufficient seriously to disturb the arrangements of the Non-Ferrous Metal Control. It is probable that the brass-making industry is the largest consumer of copper, and the firms engaged in this work are fully employed. The Non-Ferrous Metal Control, naturally, emphasises the necessity for economy in the use of all non-ferrous metals, including copper, and licences to acquire are only issued when the material is needed for an essential purpose. . . . The tin position is practically unaltered. Side by side with efforts to increase production there are continual efforts to economise in the use of the metal. The satisfactory feature of the tin position is that it has been found possible to maintain full supplies to the war industries, although at the expense of drastically cutting down the use of tin for other purposes. . . . There are no new features in the lead position, either in Great Britain or in the United States. Consumption is upon a heavy scale, although very little of the metal is made available for civilian purposes. Fortunately, the course of the war does not appear to have interrupted supplies of lead to this country, and no reports are current of firms having to go short of their requirements. . . . The spelter position is tight, but by careful supervision of distribution the Non-Ferrous Metal Control has maintained full supplies to firms engaged upon essential work. The demand for war purposes is on a heavy scale, and it says much for the planning of the authorities that the situation is so satisfactory. The arrivals in this country appear to be adequate, but there is no surplus available to meet civilian requirements ; in fact, supplies of this metal for ordinary commercial purposes have been cut down more severely than in the case of any other metal.

Notes and Memoranda

Rail and Road

JAPAN'S ROAD PROGRAMME.—Not content with its ambitious schemes for roads in Indo-China and Malaya, Tokyo is proposing to modernise more than 9000 miles of roads in occupied Northern and North-Western China. This programme is in addition to the new roads which have been completed in those regions in the past five years. The five-year scheme for Manchuria, involving the construction or modernisation of 12,420 miles of roads, will be completed by the end of the current year, if Japanese reports can be relied upon.

CANADA'S HIGHWAYS.—The completion of the Alaska road from Edmonton has been followed by further extensions of Canadian highways. The next to be constructed is a hundred-mile road to connect Prince Rupert with the British Columbia and Trans-Canada highway systems. Contracts have been awarded to seven Canadian firms. The highway will connect with the British Columbia road system at Cedarvale, B.C., and will be joined to the Trans-Canada highway by existing roads through Hazelton and Prince George, and the Cariboo highway connecting with the Trans-Canada highway at Cache Creek. The contracts call for completion in the spring of 1943.

TRANSPORT IN SPAIN.—Acting under instructions from the Spanish Ministry of Public Works, a body known as the General Direction of Railways, Tramways, and Road Transport has under consideration a scheme for the general electrification of the whole railway system, broad and narrow gauge, including also road transport, where possible. The project aims at reducing the consumption of scarce fuels by a generally extended use of electric traction. Meantime, the trolleybus service has been extended in Barcelona, and now the Valencia Tramways Company proposes to convert one of its lines for use by trolleybus and provide an extension of the system over all its rural lines. In Cordoba, Tarrasa, and Jerez de la Frontera similar schemes are being worked out.

AUSTERITY ROLLING STOCK IN GERMANY.—Before the war the German State Railways introduced locomotives of a standard type, known as "Series 50." To meet war conditions, another has been designed in which, of the 6000 components employed in the "Series 50" locomotive, some 1000 have been eliminated altogether and 3000 have been modified or altered. This new type represents a saving of 26 metric tons of steel and non-ferrous metals. Also some 6000 working hours are saved. The former type of locomotive, with its tender, required 165 metric tons of steel and other materials before any machining was done. The "War" locomotive, with its tender, calls for only 140 tons. New types of goods wagons and of guards' vans have also been developed, in which all non-essential parts are omitted.

DEMOLITION CHEAPLY DONE.—Two years ago a short railway line in Pennsylvania was closed, and the metals removed, save for a trestle viaduct, 1800ft. long and 165ft. high. The problem was to demolish this cheaply in what was wooded country. To do this two spans at one end were removed, along with horizontal and diagonal bracings from the two lower storeys in each tower. The permanent way, anchor bolt, and expansion joint connections had been previously removed and severed with acetylene cutters respectively. By attaching a steel cable and hauling on it with a hoist mounted on a lorry, it was then a simple matter to cause the greatly weakened structure to collapse endwise, like the proverbial pack of cards. The whole was then cut up on the ground into conveniently sized pieces with acetylene cutters and removed in lorries.

Air and Water

A GREEK DESTROYER.—A new Greek destroyer, named the "Miaoules," has been commissioned at a North-East shipyard. The ceremony was attended by King George of the Hellenes. This is the fourth destroyer built at the yard in recent months for the Greek Navy.

AIR TRANSPORT IN THE FUTURE.—The Hon. W. L. Runciman, director-general of the British Overseas Airways Corporation, addressed a recent luncheon meeting of the Institute of Transport on the subject of air transport's future, and referred to a number of factors which might modify some of the views of its possibilities which are entertained. He concluded his address by stressing that air transport was first and foremost transport, and that an aeroplane was only another vehicle. The business of carrying people and things about the world in an aeroplane and the business of carrying them about in a ship or a railway train or a truck were much more alike than air transport was like air fighting or air bombing. He was convinced that now and in the future there was a place for every form of transport, and that all would find plenty of opportunity to exercise their wits in discovering how to carry the greatest possible loads in the best possible ways.

PRINCE EDWARD ISLAND.—A proposal is afoot to erect a 3000-ton dry dock at Southport, P.E.I. The dock, which might cost 500,000 dollars, would accommodate vessels as large as the car ferry "Prince Edward Island." The site suggested may be built on the one selected some years ago at Southport by the Federal Government.

WOODEN TUGS.—Six sea-going wooden tugs are at present under construction by the Standard Shipbuilding Corporation in California, to the order of the United States Maritime Commission. These vessels, which will be 150ft. long and can be used for deep-water work, are being built as propulsion units for the wooden barges now being constructed to ease the increased demand for cargo tonnage.

Miscellanea

UDAIPUR LEAD-ZINC DEPOSITS.—The recently created utilisation branch of the Geological Survey of India is engaged on the study of the possibilities of lead-zinc deposits in Udaipur. These have been worked for over a century, but never adequately. They may now help to build up India's stocks of lead and zinc, which have been steadily diminishing since the occupation of Burma by the Japanese.

THE DETECTION OF CARBON MONOXIDE.—A Swedish engineer has devised an apparatus for automatically indicating the carbon monoxide content of air. The apparatus is sensitive to a concentration of carbon monoxide in air of only 3 parts in 10,000. The instrument gives automatic warning at these low concentrations in from one to three minutes. Tests with satisfactory results have been carried out by the Faculty of Medicine at Stockholm and elsewhere.

THE U.S.A. BUILDS A LIGHTNING TRAP.—Towering 585ft. in the air is a massive brick stack at Anaconda, Montana, U.S.A., which is serving as a "lightning trap." It is a part of a nation-wide study of lightning being sponsored by the Westinghouse Electric and Manufacturing Company, Ltd. Spikes atop the stack are copper rods, 5ft. long, and serve as "bait" to lure lightning bolts to the stack top, thence down twin copper cables to the base, where a device known as a "fulchronograph" records intensity and duration of the stroke.

GRAPHITE FROM MADAGASCAR.—Sixty per cent. of the total normal output of graphite is said to find its way into foundries and dry battery factories. Almost inexhaustible deposits of large and tough crystalline flake occur in Madagascar of the grade employed in the manufacture of metallurgical crucibles and it is classed as a "critical" mineral. Graphite has been mined in almost every country, yet Ceylon and Madagascar are the only countries which have been able to get prices for the material sufficiently high to permit export on a large scale.

A NEW USE FOR SLUDGE.—Dried digested sludge, a by-product from sewage treatment, has been adapted in the United States to camouflage purposes as a ground cover material. This material, almost black in colour, is freed from objectionable odour. It is spread to a depth of several inches over the entire site. On one scheme 30,000 tons of the sludge obliterated the reflection from the light-coloured soil that was exposed during construction operations. Later, because of its fertilising value, the sludge is expected to serve as a good base for quick growth of grass.

"A HANDBOOK OF EMPIRE TIMBERS."—The Department of Scientific and Industrial Research has been informed by H.M. Stationery Office that copies of the 1939 edition of its "Handbook of Empire Timbers" have now become available, and may be obtained from the Sales Offices at 3s. 6d. (or 3s. 9d. post free) per copy. In view of the numerous inquiries respecting the uses of Empire timbers which have been received by the Department's Forest Products Research Laboratory, it is hoped that this intimation will reach those most interested. The handbook contains general descriptions of a large number of Empire timbers, their strength, seasoning, and other properties, working qualities, and uses. Additional information on some of the timbers dealt with and on sixteen species not described in this edition will shortly be published by H.M. Stationery Office in a War Emergency Supplement. Attention is particularly drawn to the cancellation of data on the seasoning of balsa and to their substitution by new information on recent work.

JAMAICA MAY HAVE BAUXITE.—The discovery of bauxite deposits which could be worked from Kingston has been followed by an order by the Government of Jamaica that any bauxite or other minerals worked on the island shall become the property of the King, and dealt with in such a way as the Governor thinks fit.

LOW TEMPERATURE WELDING.—A Swiss engineer and metallurgist, resident in New York, claims to have perfected a process, which is the subject of a patent, which utilises the phenomenon of eutectic fusion between certain base metals and alloys. The process is known as Castolin eutectic low temperature welding, and under it the alloys and base metals develop a strong affinity for each other, even though the melting point of the applied metal is far below that of the parent metal. Working temperatures that give good results lie between 950 deg. and 1300 deg. Fah.

WASTE PAPER EXHIBITION.—Munitions made from waste paper are now being assembled at the exhibition, "Design for Economy: Paper in Battledress," which is on view at the Ford showrooms in Regent Street, London. Two London factory girls who have just returned from a tour of the provinces, where they have already demonstrated before more than a million people, are showing visitors how the paper they save is turned into Commando demolition containers and mortar bomb carriers. The exhibition, which is open daily from 9.30 a.m. until 5 p.m., will continue until Christmas, and new exhibits will be added during next week.

SILVER IN LIEU OF COPPER.—A branch of the U.S.A. War Production Board, responsible for substitution of materials where possible, has reported that 34,000 tons of Treasury silver has been utilised so as to save copper. Much of it has been turned into bus-bars and windings for electrical transformers in new war plants. The conditions laid down for the employment of the silver are:—(1) That the works in question require large quantities of silver instead of copper for their operations; (2) that these works are in constant operation and are thus able to make the maximum use of the metal; and (3) that the works can conveniently protect the silver. Actually the U.S. Treasury has no right to dispose of its silver. It can only lend it for a "non-consuming purpose," which allows the return of the silver at the end of the war.

Personal and Business

MR. HALFORD W. L. REDDISH, chairman and managing director of the Rugby Portland Cement Company, Ltd., has accepted the chairmanship of the Cement and Concrete Association for the third successive year.

THOS. W. WARD, Ltd., informs us that the staffs of the Grays Wharf, Titan and Silvertown works have been centralised with the London office at Brettenham House, Strand, W.C.2, and the co-ordination of affairs is in the hands of Mr. Arnold Carr, director.

LIEUT.-COLONEL H. B. RIGGALL has been elected a Vice-President of the British Engineers' Association. He is a director of Ruston and Hornsby, Ltd., and of Davey, Paxman and Co., Ltd., and has been a member of the B.E.A. Council since 1935. Mr. A. McKinstry, deputy chairman and managing director of Babcock and Wilcox, Ltd., has been elected to the Council of the Association.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institution of Mechanical Engineers

To-day, Dec. 18th.—Storey's Gate, Westminster, S.W.1. "The First Gas Turbine Locomotive," Dr. A. Meyer; "A New Rotary Compressor," A. J. R. Lysholm. 5.30 p.m.

Institution of Production Engineers

To-day, Dec. 18th.—N.E. SECTION: County Hotel, Newcastle. "Line Production of Machine Tools," Mr. Rendall. 6.15 p.m.

Royal Statistical Society

To-day, Dec. 18th.—INDUSTRIAL APPLICATIONS GROUP: E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, W.C.2. Discussion, "The Relation Between Design Tolerances and Control Limits in Manufacture." 6.30 p.m.